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THE FILTRATION OF CITY WATER SUPPLIES, WITH SPECIAL REFERENCE TO THE NEEDS OF THE CITY OF PHILADELPHIA.

The subject above stated was announced as the question for discussion at the stated meeting of the Institute, held Wednesday, March 18, 1896.

The discussion was opened by the reading of the following paper:

AN ARGUMENT FOR THE FILTRATION OF WATER DRAWN FROM THE SCHUYLKILL RIVER FOR DOMESTIC SUPPLY.

BY EDWIN F. SMITH, C.E.

The Schuylkill River, at the time when it was first taken for the water supply of the city of Philadelphia, early in the century, flowed through a region heavily timbered with oak, pine and hemlock—an ideal source of supply. About one-sixth of its water shed (310 square miles) is north of the

Blue Mountains, in a country not adapted to agricultural pursuits, and which, at that early day, was almost without human habitations. South of the Blue Mountains the valley of the stream widens, and its broad acres contain one of the most fertile agricultural regions of the State, embracing, above the city of Philadelphia, an area of 1,590 square miles, which, as early as 1800, was fairly well settled by a farming community.

From that day to this, the stream has been gradually changing in character. The discovery of anthracite coal at the head waters of the stream was closely followed by the chartering of the Schuylkill Navigation Company, in 1815, and the building of dams and canals, for the creation of a slack-water navigation. An impetus was given to business of all kinds in the valley, and the little settlements grew to towns and cities. The woodsman's axe was busy, as, unfortunately, it always is in such a country, and in the first half of the century, sad inroads had been made in the noble forests bordering the "hidden river." From that period dates its deterioration.

The pollution of the river above Flat Rock Dam may be said to date from the year 1850. Prior to that, the towns were small and without sewers, and the manufacturing industries, even at Manayunk, had not grown to such a size as to perceptibly influence the purity of the river water. The volume of flow of the stream was large as compared with the inflow of polluted water, but the cutting off of the timber had already begun to effect a change in the flow, the floods becoming more destructive, and the periods of low water more protracted.

Viewing the Schuylkill as a water supply stream to-day, after a period of deterioration of nearly half a century, the change is very marked.

In 1850, there were thirty-two pools formed by the dams of the Schuylkill Navigation, on the 108 miles of river from Fairmount, at Philadelphia, to Port Carbon. These pools aggregated 48 miles in length, and if there is any merit in the theory of subsidence as a means of purification of water, they performed a part in holding back the mineral

matter at the normal flow of the river. At the present time, there are nineteen dams in the river, the thirteen remaining ones above the Blue Mountains having been removed, and the river restored to its original channel and natural slope.

The effect of this change upon the water supply of the city of Philadelphia is easily understood. Prior to 1890 steam dredges were constantly at work in the pools of the upper river, removing the deposits of culm washed down from the anthracite collieries, and of sand and debris, resulting from the scouring of the banks of the stream and its tributaries after the cutting off of the timber.

Now, in this 20 miles of river, there is no agency at work to arrest the flow of coal dirt, but instead, when the river is in flood, the work of disintegration of the particles is hastened by the flow over the bed of an open river with considerable declivity. The presence of coal dirt is very perceptible, at Philadelphia, in the black water which comes in every freshet with what is called the second rise of the river.

Below the Blue Mountains, in the second division of the river already referred to, the floods bring down the yellow clays of the limestone regions in Berks and Montgomery Counties, the red shale of the lower tributaries of the Perkiomen and other streams, and the washings from the surface of an extended agricultural district. The chrome-yellow, and at times the reddish color of the water, is a sufficient indication to those familiar with these streams that the lower river is in flood.

These are the elements in the water supplied to the city for domestic purposes that cause discomfort to its citizens and provoke unfavorable criticism as to its purity. But however uncleanly it may be, and *unsuitable* for any domestic and manufacturing purpose, it does not follow that water impregnated with pulverised anthracite coal and with earthy matter is dangerous to health. The unsightly water is not always impure, and the clear, sparkling water is not always a pure and safe one for drinking purposes.

There are, however, sources of pollution in every river

flowing through a fertile and well-populated district like the Schuylkill Valley, which must be guarded against in some way, if the health of any community using the river for a domestic supply is to be preserved.

First and most important of these to Philadelphia is the pollution of the river within the city limits.

Much has been done by the city, since the year 1865, to prevent this. The creation of Fairmount Park, the improvement of the Wissahickon Valley, the building of the Mantua Creek sewer on the west side, and the Manayunk intercepting sewer on the east side of the river, the building of river walls on either side of Fairmount Pool—all at a great cost—are indicative of the desire of the people that everything possible should be done to protect and preserve the purity of the water supply. A few more sources of pollution might be removed at a very small cost, namely, the indiscriminate dumping of ashes and refuse into the river at Manayunk, and the flow of sewage through the sewers into Fairmount Pool, in cases where it has not already been intercepted.

Second, the pollution of the river by the towns and cities above Philadelphia.

This has not, up to the present time, been a serious matter, but it may become serious in the near future, unless preventive measures are used.

Seven cities and towns, namely: Reading, Pottstown, Spring City, Phœnixville, Norristown, Bridgeport and Conshohocken, with a total population of 110,000, pump daily (approximately) 11,500,000 gallons of water from the Schuylkill for domestic and manufacturing purposes. They are all equally interested with the city of Philadelphia in preserving its purity. Nevertheless, without the restraining arm of the law, exercised through a State Board of Health, as is done in Massachusetts, Connecticut and a few other States, the purity of the water cannot be preserved. With the multiplication of conveniences of living, and the intro-

duction of modern water appliances into dwellings and public buildings, there comes the demand for sewers, to take the place of cesspools and to carry off waste water. Sewers must discharge somewhere, and there is nothing so easy and apparently so economical in the eyes of a taxpayer as to empty them into the river.

Fortunately for Philadelphia, there has been very little of this evil up to the present time; but it is on the increase, and, in the natural course of events, will grow very fast. Within a year the city of Reading, with a population of 72,000, has completed the sewerage system of its first district, covering about one-third of the city. The sewers, instead of discharging into the river, are connected with a sanitary sewage system, with a disposal plant, and arrangements for burning the excrement and refuse solid matter, and filtering the liquid through sand filter beds, before discharging the effluent into the rivers. *Unfortunately, this system is not at the present time in use,* the sewage being allowed to flow through a by pass directly into the river. Few house connections have as yet been made; but as they are now allowed by the city authorities, the increase in number will be very rapid, and, therefore, in the interest of the towns on the river below, and the city of Philadelphia, it would appear to be wise to limit, in some way, the use of the by-pass. As a matter of ordinary prudence, it is best that crude sewage should be kept out of streams; it is in fact absolutely unsafe to allow it to flow into a stream which, at any point below, is the source of a public water supply.

I have indicated two urgent reasons why the city of Philadelphia should filter its entire supply from the Schuylkill, namely:

(1) To remove sedimentary matter, mineral and organic, and filth brought down by floods, so as to clarify the water and make it *sightly and fit for domestic purposes.*

(2) To remove, as far as possible, organic matter contained in sewage from cities and towns in the valley, which is a constant menace to the health of those obliged to use the water for drinking purposes.

No State in the Union has done more or better work in this direction than the State of Massachusetts, and its example might profitably be followed by Pennsylvania, to whose State Board of Health the Legislature so grudgingly gives inadequate appropriations.

To the State of Massachusetts we are indebted for the solution of two important questions in connection with the filtration of a polluted water supply. I quote from the report of the Massachusetts State Board of Health, for the year 1894, as follows:

"(1) With properly constructed filters, which are carefully operated, at a *uniform moderate rate of filtration* (not exceeding 5,000,000 gallons per acre, daily), satisfactory hygienic results may be regularly obtained with the Merrimac River water.

"(2) The cost of rendering, by filtration, a polluted water supply safe for drinking purposes is *considerably less* than was formerly supposed to be the case."

These statements are based upon the experience gained in operating the sand-filter beds connected with the water supply of the city of Lawrence, Mass. In this connection it may be stated that the valley of the Merrimac is much more densely populated than that of the Schuylkill, and the problem of filtration is a more difficult one.

What is being done at Lawrence with the Merrimac River water can be done at Philadelphia with both the Schuylkill and the Delaware. Filtration is being carried on now throughout the city for both household and manufacturing purposes—and, in some instances, on quite a large scale. I submit the results of a chemical analysis of sand-filtered Schuylkill water drawn from the Market Street main, the filters having a rated capacity of 450,000 gallons per twenty-four hours. This examination is made disinterestedly for the purpose of following up and regulating the working of the filters, and of preserving a record of the condition of the water analysed each month.

The results show the Schuylkill water to be not so bad as it has been represented to be; but, on the contrary, they prove it to be a safe drinking water, if properly filtered.

ANALYSES OF SCHUYLKILL WATER, AFTER PASSING A MORRISON & JEWELL PRESSURE FILTER.—(O. S. DOOLITTLE, CHEMIST.)

	PARTS PER MILLION.						GRAINS PER GALLON.		
	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrates.	Nitrites.	Required Oxygen.	Organic Residue.	Mineral Residue.	Total Residue.
1894.									
July	0·038	0·066	6·37	0·70	trace	0·34	—	6·89	12·90
August	0·022	0·064	3·90	2·99	·0034	1·90	—	7·98	10·96
September	0·030	0·076	10·38	0·23	trace	1·65	—	7·98	10·40
October	0·026	0·010	5·93	0·16	trace	1·45	—	4·32	6·09
November	0·032	0·100	4·94	0·20	trace	1·75	—	4·98	6·62
December	0·026	0·022	1·08	9·60	trace	0·85	—	4·84	5·56
1895.									
January	0·028	0·032	0·495	1·30	trace	0·95	—	4·10	5·54
February	0·052	0·044	4·95	3·00	trace	1·12	—	5·44	7·49
March	0·045	0·096	4·44	0·70	trace	1·50	—	3·84	4·97
April	0·016	0·068	4·88	0·30	trace	1·45	—	4·33	5·62
May	0·018	0·048	4·95	2·00	none	1·55	—	4·04	6·26
June	0·014	0·060	5·44	4·00	trace	1·25	—	5·19	6·23
July	0·054	0·048	5·44	2·40	trace	2·45	—	—	6·05
August	0·014	0·090	4·94	0·68	trace	1·85	slight	—	6·46
September	0·008	0·066	6·86	0·64	trace	2·25	slight	—	6·53
October	0·046	0·088	7·97	3·60	trace	1·90	slight	—	7·04
November	0·050	0·096	7·50	0·54	trace	2·35	slight	—	7·30
December	0·040	0·058	7·00	1·70	trace	2·15	slight	—	8·08
1896.									
January	0·090	0·033	6·48	2·00	trace	2·175	slight	—	5·57
February	0·160	0·074	6·00	3·00	none	2·20	slight	—	4·85

NOTE.—Sand filtration without the use of alum, from July, 1894, to January, 1895, inclusive. Alum used as a coagulant, from February, 1895, to February, 1896, inclusive.

RESULTS OF CHEMICAL ANALYSIS.

One sample per month of Schuylkill water, for twenty months (July, 1894, to February, 1896, inclusive) from service mains in Ninth Ward, city of Philadelphia, after the water had passed through pressure filters, of a capacity of 450,000 gallons per twenty-four hours, using sand as the filtering medium:

Parts in 1,000,000.	Highest in 20 Months.	Lowest in 20 Months.	Average of 20 Months.	STANDARD OF PURITY. Dr. Leeds' Maximum.*	STANDARD OF PURITY. Proposed Jersey City New Water Supply.
Free ammonia . . .	0·16, Feb., 1896	0·008, Sept., 1895	0·0404	0·12	0·05
Albuminoid ammonia	0·10, Nov., 1894	0·010, Oct., 1894	0·0619	0·28	0·15
Required oxygen . . .	2·45, July, 1895	0·34, July, 1894	1·6532	5·00	—
Nitrates	9·60, Dec., 1894†	0·16, { Oct., 1894 May, 1895	1·987	5·00	2·00
Nitrites	0·0094, Aug., 1894‡	None, Feb., 1896	Trace	0·01	None
Chlorine	10·36, Sept., 1894‖	0·495, Jan., 1895	5·4972	10·00	8·50

* See Philadelphia Water Department Report for 1883. Page 243.

† Heavy rain fall and flood in river three days preceding the taking of sample.

‡ Sample taken during the period of very low water in the river, extending back more than thirty days.

‖ Sample taken following a heavy local storm causing a sudden rise in the river.

The question for Philadelphia is: what shall be done to preserve and enlarge its water supply? The city has even now reached a crisis, and is pumping, in seasons of drought, in excess of the ability of the river to furnish water. For twenty-seven years, since 1869, the question has been before successive administrations, and has been debated in Councils, only to be shirked and handed down to their successors.

I cannot hesitate, therefore, to express my conviction that a great mistake was made in the framing of the "Bullitt" Bill, upon which the present city government is based, in not vesting the control and management of the water supply in a Board of Water Commissioners, instead of in Councils and a cumbersome "Watering Committee" of Councils. Such a board should be non-partisan, and limited in number to four or six members, equally divided between the two leading political parties, with power to use the surplus revenue of the department for the extension of the water works, when necessary.

It is interesting to note that the system of placing the management of water works in the hands of Councils and

similar governing bodies does not find favor in the United States. It does not clearly fix the responsibility for the failure to provide for a matter of such public interest upon which the well-being and health of the community depends. Out of 225 public water works, embracing the principal cities and towns in United States in 1890–91, only 23 were so managed, the control of the remaining 202 being vested in a Board of Public Works, or a Board of Water Commissioners.

When will the City of Philadelphia awake from its long sleep? When will it throw off its lethargy and command those who are in power, and who could act if they would, to cease postponing action upon so vital a question?

PHILADELPHIA, March 16, 1896.

The Secretary read the subjoined letter, received from Dr. Leeds:

The Secretary of the Franklin Institute.

SIR:—I regret that my duties here will prevent my acceptance of your invitation to attend the meeting to-morrow evening, and take part in the discussion upon the subject of filtration, with especial reference to the present needs of Philadelphia. Inasmuch, however, as I regard those present needs as imperative, I should be sorry to let this opportunity pass without urging the corresponding need of appropriate and corresponding action.

During the years 1881, 1882 and 1883 the city expended $125,000 in an elaborate investigation of the whole subject of a future water supply. The details will be found stated at great length in the reports of the Chief Engineer for those years, and also the conclusions arrived at, which were that recourse must be had either to some distant point, like the Delaware at Point Pleasant or even as far as the Water Gap; or if this were not done, that the present sources of supply should be purified by filtration. This was thirteen years ago, and the same recommendation has been made by the head of the Water Department during each succeeding year, and reiterated by the chemists of the Board of Health, the Academy of Medicine and by the citizens' associations. As

chemist of the Water Department during the progress of the survey, I advocated the plan of not abandoning our present sources of supply, but of purifying them.

My reason for so doing was that the analyses and examinations showed that the Delaware River above Point Pleasant, or above the Water Gap, and the upper waters of the Perkiomen, the Lehigh River, the Neshaminy and the Tohickon were not entirely free from contamination. Even if recourse were had to these water-sheds, there would come a time in the future when the water drawn from the best of them would have to be purified by filtration. I asked many city engineers in England why they maintained great systems of filter beds for water supplies, which, in their quality, were fully equal to that of the Delaware at Point Pleasant, or the Perkiomen above Zieglersville. They said that public opinion demanded a water supply which should at all times be free from color and sediment, and that the only practicable method of securing these ends was by filtration. The most noteworthy instance of this kind was in connection with the new supply of Liverpool. This is taken from Vyrny Lake, situated 40 miles away in the mountainous part of Wales, and filled with water so pure that it is customarily referred to by chemists as exhibiting a high grade of purity. The well-known engineer, Mr. Deacon, at that time in charge, on my expressing surprise that in case of water of this kind, he should regard it necessary to establish along the line of conduit a system of filter beds, said that he was compelled to do so by force of public opinion.

The future filtering systems of Philadelphia should, however, be installed at present in connection with the present pumping stations. The water of the Elbe, at Altona, contains rarely, if ever, less than 10,000 bacteria per cubic centimeter, usually over 20,000, and frequently 40,000 or more. This, it will be acknowledged, is densely populated sewage-holding water; yet this fact did not prevent the Altona authorities from successfully filtering the Elbe water and thus escaping the cholera epidemic which so afflicted the neighboring but unprotected city of Hamburg. What 20,000 and 40,000 bacteria per cubic centimeter means, I can best illustrate by reference to the bacteria in the Passaic

River. This river receives the sewage of Paterson, and, at a point below, is pumped directly into the reservoir and mains of Jersey City. Ordinarily, at the point of intake, it contains from 7,000 to 13,000 bacteria, and yet this unfiltered water renders Jersey City the most subject to typhoid fever of any city in New Jersey.

Granting that a system of filtration should be established, the preliminary expenditure of $250,000 to settle upon the best system for such water as is supplied from the present intakes on the Schuylkill and Delaware, would be the best way to save money in the end. It would require many pages merely to mention the questions open to discussion, in attempting beforehand to decide upon the system which Philadelphia should adopt. The relative merits of "mechanical" and "natural sand" filtration have never been tested on a proper scale by filter plants operated upon and running side by side; neither has the relative cost of removing dirt and bacteria by means of alumina, oxide or iron or similar coagulant, in comparison with slow subsidence through sand only. The proper head of water in a gravity filter; the proper depth and character of sand; the relative merits of continuous and intermittent filtration; the advantage of aeration as an adjunct, etc.—all of these points can be properly settled, not by discussion, but by actual trial. In 1883, the writer proposed the use of aeration as an adjunct to purification. It was first tried in connection with the Philadelphia water at the Corinthian Basin, and since that time, in one or another form, the aeration of the water has become a feature of water purification in many places. The city appropriated $10,000 for purchase of the aerating machinery, which might still be utilised if it has not fallen to decay in the meantime.

In conclusion, I would reiterate my often-expressed convictions that the only economically practicable way in which Philadelphia can be freed from the stigma of its present high typhoid death-rate is by putting in a system of water purification on some such lines as indicated above.

Yours, very truly, ALBERT R. LEEDS.

STEVENS INSTITUTE OF TECHNOLOGY,
HOBOKEN, March 17, 1896.

MR. L. Y. SCHERMERHORN.—During the recent freshet in the Schuylkill River, extending from February 7th, at 7.30 A.M., to February 11th, at 12 M., or during 100 hours, I made an approximate determination of the volume of water passing over the Fairmount Dam during this interval, and also the relative quantity of solid material held in suspension by the water, under the following conditions:

During the freshet the depth of water on the crest of the dam varied from 1·5 feet to 7·7 feet. The volume of water passing over the dam during the interval of 100 hours named, as calculated for the varying depths by accepted hydraulic formula, was found to be about 9,350,000,000 cubic feet. On February 9th, while the depth of water on the crest of the dam was about 2 feet, a sample of the city water was drawn from a house spigot and found to contain $\frac{1}{1200}$ part by volume of solid material.

It will be noted that the volume of solid material was determined at a time when the freshet was below its average height, and after the water had passed through the reservoir, and some sedimentation had ensued; it is therefore assumed that the determination of $\frac{1}{1200}$ part of solid material is a reasonable assumption to be applied to the entire volume of the freshet.

On such a supposition the volume of solid material carried by the freshet waters during the 100 hours named would be

$$\frac{9,350,000,000}{1,200} = 7,791,000 \text{ cubic feet,}$$

or about 290,000 cubic yards.

Assuming that the average daily quantity of water used by the city of Philadelphia is 220,000,000 gallons, or 29,300,000 cubic feet, and further, that this volume contained during the freshet the volume of solid material named, then in that event it was equal to

$$\frac{29,300,000}{1,200} = 24,400 \text{ cubic feet}$$

of solid mud contained in our water supply during one day of the freshet. An ordinary one-horse cart contains

about 24 cubic feet; the above-named volume of over 24,000 cubic feet of mud would fill at least 1,000 carts, and if placed in close file would form a line nearly three miles in length; if placed on Market Street, would form a line of carts extending from its foot to Thirty-sixth Street, West Philadelphia. What would the citizens of Philadelphia think if they really saw such a procession on its way to our reservoirs with the intention to deposit such an amount of mud into our water supply for one day?

If my determinations have been reasonably correct, the Schuylkill River was, during the time named, doing what might have been done with no greater disadvantage or different results by the thousand carts loaded with mud.

MR. JOHN C. TRAUTWINE, JR., Chief of the Bureau of Water, took occasion to protest against the popular indiscriminate denunciation of members of Councils, which gives the impression that Councilmen, generally, are strangers to the taste of water, and are, therefore, indifferent to the needs of the city in this respect; whereas, even those who have been least hopeful of the passage of the pending ordinance have recognised, from the first, that there was a good working majority in favor of it, and have doubted only the possibility of obtaining the two-thirds vote necessary in cases which, like this, involve an appropriation.

He then presented a report of the results of investigations of the relative merits of sedimentation and filtration in clarifying and purifying water.

When this matter was first mentioned in Councils he shut off the smallest division of the East Park Reservoir, and proceeded to take samples from day to day, and to have them tested, bacteriologically and chemically, by Dr. A. C. Abbott, of the University of Pennsylvania. The results confirm those given by Dr. Percy Frankland in his "Micro-Organisms in Water." The first day's sedimentation left 637 out of 1,000 microbes in a given quantity of water, while the second day reduced this number to 131. From that time forward, during the remainder of the ten days through which the experiment was continued, the experiment showed but little change either way.

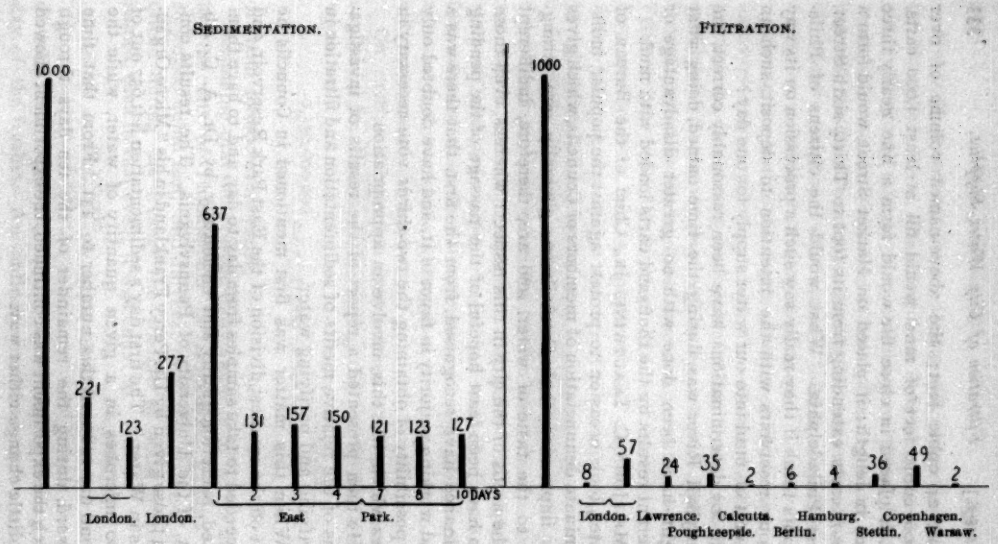


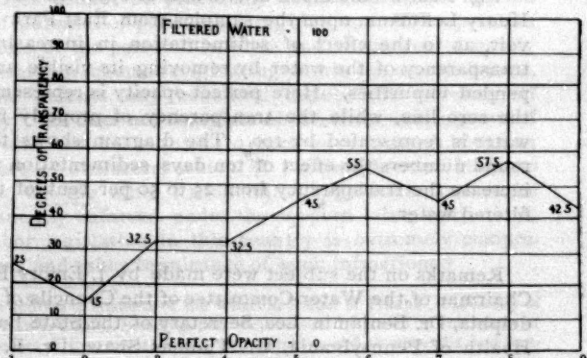
FIG. 1.—Bacteriological effects of sedimentation and filtration.

Filtration, on the contrary, effects the removal of 98, or more, per cent. of the bacteria.

These results were illustrated by means of the lantern, and samples were exhibited showing the raw water, and the effect of twelve days of sedimentation. The latter showed a slight improvement in the matter of clearness.

A sample of filtered water, taken from the tap in the City Hall, showed a rather better result, the water being clearer and whiter.

Fig. 1 shows the effects of sedimentation and of filtration in reducing the number of bacteria, the columns on the



No. of sample,	1	2	3	4	5	6	7	8	9
Date, March, 1896,	6	7	8	9	10	11	13	14	16
No. of days allowed for sedimentation,	0	1	2	3	4	5	7	8	10

FIG. 2.—Effect of sedimentation in increasing transparency.

left representing the effects of sedimentation (including those obtained at East Park Reservoir, as above stated), while those on the right represent those obtained by filtration, as derived from several authorities.

In each case the figures refer to a quantity (generally less than a cubic centimeter) of the raw water containing 1,000 colonies of bacteria. This quantity is represented by the line marked 1,000 at the left of each half of the diagram. On the left the next two columns, marked 221 and 123

respectively, show the results of sedimentation in a first and a second subsiding reservoir (time of subsidence not stated), as given by Percy Frankland in his "Micro-organisms in Water," while subsequent filtration reduced the number to 8, as indicated by the first column on the right.

The third column on the left, marked 277, shows the result of sedimentation in a large reservoir, where the water was allowed to settle from one to six months, and the second column on the right, marked 57, shows the effect of subsequent filtration. These figures also are taken from Percy Frankland's work.

Fig. 2 shows the mean of two sets of observations by Dr. Henry Leffmann, upon the samples from East Park Reservoir, as to the effect of sedimentation in increasing the transparency of the water by removing its visible and suspended impurities. Here perfect opacity is represented by the zero line, while the transparency of properly filtered water is represented by 100. The diagram shows that in round numbers the effect of ten days' sedimentation was to increase the transparency from 25 to 50 per cent. of that of filtered water.

Remarks on the subject were made by J. Emory Byram, Chairman of the Water Committee of the Councils of Philadelphia, Dr. Benjamin Lee, Secretary of the State Board of Health of Pennsylvania, Mr. Thomas Shaw, Dr. E. Goldschmidt, and others, the tenor of which was uniformly and strongly in favor of filtration as a remedy for the existing evils of our local water supply.

At the close of the discussion, the following resolution, offered by Mr. Shaw, and numerously seconded, was adopted without dissenting vote:

"*Resolved*, That it is the sense of this meeting that the Councils of the city of Philadelphia should make an appropriation sufficient to satisfy the requirements of the Director of Public Works for the erection of an experimental filtration plant."—W. H. W., *Secretary*.

PENDING PROBLEMS FOR WAGE-EARNERS.*

BY A. E. OUTERBRIDGE, JR.

In studying the important question of management of employés of industrial establishments from a common-sense as well as just and humanitarian point of view, it is necessary to remember that a factory is not an eleemosynary institution; the functions of the two are radically different, and experience has proved that modern manufacturing industries cannot be practically conducted under the old idea of paternal or patriarchal regulations. The operative is jealous of his personal freedom and suspicious of purely philanthropic schemes originating within the establishment, and he resents any beneficial regulations savoring of charity. He does not complain of the strict enforcement of just rules, but he is quick to take advantage of laxity on the part of overseers, which, if continued, soon leads to chaos. On the other hand, unjust regulations cannot be permanently enforced under the modern labor restrictions, for labor legislation in this country is extremely comprehensive, and takes cognisance of such infractions.†

* An address to students of the Wharton School of Finance, University of Pennsylvania, Class in Sociology, on the occasion of a visit to the works of Wm. Sellers & Co., Incorporated, Philadelphia; with an appendix and foot-note references added thereto for this publication.

† The labor laws differ greatly in the different States. Massachusetts has led the way in such legislation, and the other States are following in her footsteps. Most of these laws increase the responsibilities of employers, thus: Methods of protection from fire and accident must be provided in all factories and workshops, and employers cannot by contract exempt themselves from liability for injuries to an employé. The buildings must be provided with proper sanitary arrangements; each room where machinery is placed must be connected with the engine room by speaking tubes, electric bells, or appliances to control the motive power.

The most minute regulations exist relating to the entire economic system of factory construction, operation and inspection; and laws governing the payment of wages, exemption from fines or garnishment of wages, or tools of trade for debts, etc., cover every phase of employment growing out of the factory system, and are distinctly favorable to labor. (See *Eng. Mag.*, September, 1895).

In some instances where labor legislation has been elaborated to a degree which was unduly oppressive to employers, it has served to restrict industrial development, reacting upon the intended beneficiary—the employé—and has necessitated the abandonment of such policy. The "granger legislation" relating to railroads in some of the Western States affords a well-known illustration of this tendency.

Employés are no longer ignorant of their rights or privileges, and employers, as a rule, neither care nor dare to trample upon them; but experience has also proved that wherever numbers of men are massed together, a certain degree of strict government is essential to the preservation of order and the proper conduct of business.

Many of the rules and regulations of workshops and factories which to the uninitiated appear harsh or unjust, are, in reality, necessary to protect the faithful employé from impositions of shirkers, of whom there is always a certain number even in the best-regulated establishments.

It is a favorite observation with writers on social and political economy that the world is continually passing through periods of "social evolution." One of the latest and most popular of these authors (Benjamin Kidd) calls the present time "the most remarkable epoch in the history of human thought." Portents of impending changes in the established order of things, affecting the very foundations of society and the welfare of mankind, are frequently revealed to the innate perceptions of such writers; and it would seem from some of these—more especially the German authors—that the industrial world is now upon the verge of a social cataclysm, out of which a new civilisation, the resultant of many opposing forces, would be evolved. Such prophecies (like Benner's) have hitherto apparently obeyed the "law of averages" with respect to the proportion of hits and misses; yet new forecasters of future social conditions, who believe that they perceive shadows of "coming events" cast before, continue to decipher these signs according to their introspective vision rather than through the light of past experience.

The fundamental principle of the Malthusian theory, that

population tends to increase in geometrical progression, and that the supply of food and other necessaries of life can only be increased in arithmetical progression, tersely expressed the social problem of Malthus' generation; but the subsequent wresting from Nature of virgin soil of vast extent in India, Russia, America, and other parts of the globe, affording feeding ground for countless flocks and herds, together with facilities for plowing, sowing and reaping unlimited crops through the aid of modern agricultural machinery, and the modern methods of rapid distribution, changed all the former conditions, rendering the law inoperative during the century which has elapsed since its promulgation. Some of the more recent prophecies have proved equally abortive, and others are likely in the near future to share the same fate.

The growth of socialism in Europe during the past quarter of a century is one of the "signs of the times" which is just now affording a fruitful field for such speculations. If we permit ourselves to view the present state of civilisation through the spectacles of some of these theorists, or if we countenance the foreign socialistic propaganda, we must, it seems to me, close our eyes to the countless evidences of truly wonderful progress in mental, moral and material welfare which has been made by the wage-earning class in America during this period. The operative of to-day is not only the peer, but the superior of his predecessor in all the qualifications that form the mental gauge by which we may measure the intellectual and social relations that an individual bears to the community in which he lives.

We may freely admit the statement of the socialist that "the rich are growing richer," but it does not follow as a corollary that the poor are growing poorer. It is true that capital, through combination, has vastly increased its power to organise and prosecute industrial pursuits on a scale of unprecedented magnitude, and that, especially as the result of energetic exploitation of new inventions, large rewards have been gained by bold investors; but I claim that, in the aggregate, labor has gained a much larger share of these benefits without incurring any of the risks.

The rich pecuniary rewards which have been reaped by Sir Henry Bessemer, and by other manufacturers who were far-seeing and courageous enough to develop his cheap process of steel-making and its later modifications, make but a small item when compared to the countless millions paid to labor during the past thirty years as the result of the development of these discoveries through the aid of capital. The Bessemer process of steel-making did more than this for labor: it sounded the death knell of the most exhausting form of toil known to man, that *inferno* of labor, the puddling of boiling iron by human hands. Many similar illustrations could be given.

I claim that modern mechanical inventions have in all cases proved to be distinctively beneficial to the wage-earner: he is, through their aid, better housed, better fed, better clothed, better educated, has more numerous and better amusements, and is thus approaching more nearly to the condition of the employer. Indeed, the wage-earner to-day enjoys many advantages of civilisation which were unknown to employers of former generations.

Herr Liebknecht, the leader of the Social Democrats in the Reichstag, presented to American readers in *The Forum* "The Programme of German Socialism." I carefully studied his paper with the view of discovering, if possible, some rational explanation of the problem—"How is socialism going to benefit the condition of the working class in America?" but the question remains unanswered. It is true that figures are given showing the marvellous growth of social democracy in the German Empire since 1890, and the author glories in the title which he gives to German social democracy, viz.: "the party of the discontented;" he also perceives signs of "an impending social crisis;" he likens the struggle between socialism and the Government to the fable of the goblin and the peasant; but the introduction of such a movement into this country could, I think, be more appropriately likened to the fable of the killing of the goose that laid the golden egg.

The recent presence in this country of more than one agitator from abroad, and the industrious dissemination of

socialistic literature among our workingmen, with the evident intention of making proselytes, thereby disturbing the peace of mind of the operative, endangering the stability of our industrial laws, and tending to nullify the gain which has come to wage-earners in America through the comparative freedom from such disturbing elements, is a subject of concern to all real friends of the workingmen.

In Germany, the literature of socialism has not confined itself to agitation of labor questions, but has catered to the demand for popular reading and also for popular education. In this way it has gained the confidence of the people. "It has abused this confidence by giving distorted views of the writings of many of the greatest thinkers and educators;" it has used popular education as a club with which to beat into ignorant skulls the socialistic propaganda. The enormous socialistic vote in Germany proves the success of the force used. Such a force, if properly applied, would be immensely beneficial to humanity; but improperly used, socialism is, as Herbert Spencer declares, "the greatest calamity that has ever befallen the human race."

The most intelligible exposition of modern German socialism may be found in a little book entitled "Three Months in a Workshop," written by a student, Paul Göhre. In a prefatory note to the English translation by Prof. Richard T. Ely, it appears that "Mr. Göhre, perplexed by conflicting theories and reports touching the lot of the German wage-earners, determines to become a wage-earner himself, and, donning the garb of a workman, finds employment in a large establishment for the manufacture of machine tools in Saxony; he mingles for three months with his fellows, who never supposed him to be anything else than a wage-earner; he shares their life, participates in their amusements, attends their political meetings, and then tells what he has seen with that simplicity which is itself literary art of a high order. The narrative is plain, straightforward, truthful."

The book is more than this; it is a practical view of a subject which has been clouded in mists. The writer has shown himself a keen observer, a disinterested and enthusi-

astic investigator, having nerve to enter the factory on the lowest rung of the ladder, and to live and toil with the humblest employés, for the definite purpose of grasping the bottom facts of socialism as it is comprehended by the workingmen themselves, not as presented to the world by the leaders in the movement, many of whom do not really belong to the class they assume to represent. That Mr. Göhre should have succeeded, under these heroic conditions, in showing in his little book a clearer insight into the labor question and social democracy in Germany than can be found in many more elaborate treatises, is not altogether surprising. In the chapters, "Work in the Factory," and "The Material Condition of My Fellow-Workmen," the American student and operative will recognise abuses still existing in Germany, which our more progressive establishments have eliminated. The contrast, also, in rates of wages and quality of living with wage-earners in America will excite sympathy, but will also weld the American more firmly to the belief that the condition of the wage-earner in this country is a happy and fortunate one, by comparison; that its stability must not be jeopardised by countenancing socialistic agitation.*

In the chapters on "Political Tendencies of my Fellow-Workmen" and "Social Democracy," the student of industrial sociology will find much valuable information. In the chapters on "Moral Conditions" and "Education and Religion," ethical questions are plainly discussed. The final chapter, on "Results and Demands," will interest all read-

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* On entering the shops, Mr. Göhre received 20 pfennige (4·8 cents) per hour. Compulsory deductions were made for assessments for sick benefits, insurance, fines for lateness or carelessness, etc.

Men working at the vise earned 15 to 21 marks ($3.60 to $5.04) per week; their foremen, $5.28 to $6.72; drillers, working on time, $3.60 to $4.56. "Piece workers" made considerably more. A specially skilled workman "would receive as much as 40 marks ($9.60) per week." It thus appears that the highest wage of the most skilled operative slightly exceeds the lowest wage for unskilled labor in this country. The home life of the men is shown to be on a plane far below that of the average wage-earner in America.

Some suggestive and important information is to be gathered from a book just issued by the British Board of Trade, giving the statistics of wages paid

ers. It is shown that the labor question is not merely a wage question with the vast majority of the laboring class. It is only one factor in the movement—perhaps the most tangible, but not the most important or determinative one. "There is an ardent longing on the part of the whole class of factory labor for more respect and recognition, for greater actual and social equality in addition to the formal and political equality, which is theirs already. * * * It is the irresistible impulse to a larger intellectual freedom, the craving for the benefits of knowledge and education, and for a fuller understanding of those high and lofty problems of the human soul which, despite the universal pursuit of wealth and externals, rise up before humanity to-day, new riddles in new forms. All this, rough, discordant, full of anomalies and extravagances, yet plainly visible to the observant eye, stamps the beginning of the labor movement in Germany."

If confined to such lofty aims, the mission of socialism would be worthy of, and would command the sympathy and hearty co-operation of all enlightened people; but Mr. Göhre shows that it is necessary first to unmask the hypocrisy of social-democratic literature, to oppose the true to the false, the impartial to the partisan; he tells us that "German Social Democracy is to-day not merely a political party, not merely the promoter of a new system of economics, or even both of of these and nothing more; it is also the embodiment of a philosophy, a logical, anti-Christian, materialistic conception of the universe. Upon this materialistic system it founds its

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for manual labor in Great Britain. From this it seems that the average earned by men is $6.03 a week; by women, $3.08; by boys, $2.24; and by girls, $1.56. These are the averages of the wages of 816,106 persons. In Scotland, the rates are lower than in England by 10, and in Ireland by some 20 per cent. The best-paid trade is that of builders, and then, in order, distillers, brewers, metal workers, engineers, saw-mill workers, coach builders and printers. Railroad men average $5 a week. The chances of earning $10 a week are not common; 37 per cent. of the printers, 33 per cent. of the tinplate workers, 13 per cent. of the ship-builders, 11 per cent. of copper and brass workers and 10 per cent. of coopers attain that amount. On the whole, the report indicates that wages in all British trades are on the increase, but at a very slow rate of progress.

economic and political system. This principle, the caricature of a so-called science, worshipped by its followers, is the corner-stone of the party, gives it authority and ideals, and exercises the most fatal and lasting influence, not so much on the social and political tendencies as on the intellectual and ethical character of the whole German laboring class." This new gospel of socialism ran like wildfire among the hundreds of thousands of German workingmen. Herr Liebknecht tells us that "nearly 2,000,000 of men voted for the socialistic programme on the 15th of June, 1893, to whom must be added nearly 1,000,000 of voteless young men between the ages of twenty and twenty-five years."

The spread of socialism in Germany has now reached the degree which is popularly termed with us a "craze." Its earliest converts became its new prophets, its inspired preachers; from inner conviction they gave their whole strength, their utmost capacity, to the cause. "Wherever two or three met together, men set forth and discussed the thoughts they had imbibed from one book or half a dozen books of the new literature; sometimes fairly grasped, sometimes only half comprehended and more than half forgotten, but always brought afresh to their minds by the articles in their social-democratic paper. * * * The effect of this agitation was the one desired. Under its pressure all the old youthful training of the workman gave way, and is still giving way in every individual who brings such training with him to a factory where the spirit of social democracy prevails."

If, now, we cull out these true and noble yearnings of the workingmen, discarding the sophistries of their self-elected leaders, we find that their aims are those which have already been largely attained by the wage-earning class in America through education; and while we may reasonably sympathise with the German "party of the discontented," we have nothing to gain by the dissemination of their socialistic literature, though they have much to learn from us.

In England the socialistic movement presents a different phase of development; there are fewer factions or cliques

of socialists, and the tendency toward anarchism, while not so rabid as among the most radical wing of the party in Germany, is apparently even more generally diffused. Some of the recent socialistic literature published in England has a decided flavor of anarchism, at least in so far as it preaches the overthrow of laws by which land is held in private ownership; the private or corporate ownership of all kinds of property, factories, railroads, telegraphs, etc.; and evidences are not lacking of widespread discontent and unrest among the industrial population, which devours such literature with avidity. It is reported that 1,000,000 copies of a single book of this character have recently been sold to workingmen in England.

The latest cabled reports indicate that a reaction in labor sentiment has set in in England. There was recently in session at Newcastle a "Free Labor Congress." The president's opening address is reported to have been "a vigorous attack on trades-unions, which, he declared, were manipulated by self-seekers, whose tyranny disgraced the cause of labor." His association, he said, had already formed "boards of conciliation" at many important centers. These boards were formed of equal numbers of masters and operatives, and were all working in perfect harmony. An editorial writer, commenting upon this cablegram, says: "The revolt from trades-unions was not unexpected. It was bound to come as soon as the more intelligent workmen perceived that they could no longer own themselves, but were virtually made slaves of the lazy and inefficient members of the organisation. It is singular that this should have been perceived first in England instead of in America." This writer is evidently not well informed in the history of the rise and fall of several labor-unions in this country, which, a few years ago counted their members by thousands, where they now number units. Compared with a period of four or five years ago, the larger number of the unions have sunk into a condition of "innocuous desuetude," controlled by cranks.

Labor-unions, however, should not all be classed under one category, for some of these are beneficial organisations,

with high motives, sound constitutions, and, above all, wise leaders. Such organisations are opposed to violence and disorder, encourage harmony and arbitration, and are mutually beneficial and helpful to employer and employé; they are aiding to discourage the spread of anarchism and socialism in this country.

Socialistic theories are inimical to American ideas and principles, for the humblest workman is a free citizen, to whom a pathway is opened to the highest positions of honor and wealth. Many of our foremost men have risen from lowest origin, and have no cause to be ashamed thereof. Socialism can offer no commensurate advantages; its tendency is not to raise the masses to a higher plane, but to reduce the competent to the level of the incompetent. The world is always crowded with incompetent operatives, while at the same time there is an unsatisfied demand for the absolutely competent.

In daily friendly intercourse with workingmen, extending over a period of twenty years, I have found a prevalent idea in many minds that employers of labor are, as a class, jealous of the material advancement of wage-earners beyond a certain point; that a maximum wage is soon reached beyond which they cannot hope to pass, and that extra effort on their part would result merely in an increase of tasks without a corresponding increase of pay. This impression is more generally inculcated in the minds of operatives than employers realise, and it operates to their mutual disadvantage. Modern "piece-work" systems of pay have been devised (and are now generally practised) with a view of stimulating workmen to produce the greatest output and largest percentage of perfect work; but these elaborate systems are, to a certain extent, rendered inoperative by reason of the suspicion mentioned. That there may have been, and may still be, some ground for such impressions I do not dispute, but I do believe that a more enlightened view of the mutual relations existing between employer and employé is gradually permeating the industrial world.

The great development of mechanical invention has not only increased the demand for skilled labor by increasing

the output and opening constantly new fields of labor, but it has increased tenfold, and in some instances one hundredfold, the possible product of labor *per capita*. This is the reason why the American employer, paying the highest wages in the world, is, nevertheless, able to compete in the markets of Europe with so-called "pauper labor" in many manufactured articles.*

It has been proved by actual experiment on a large scale in certain sections of this country, that ignorant foreign pauper labor in manufacturing industries is ultimately the most costly, and the aim of enlightened employers today is not to obtain the cheapest labor but the most intelligent service. The true policy of the workingman is, therefore, not agitation but education.†

* Mr. Mulhall, the English statistician, has recently published some tables relating to the producing power of the different nations of the earth. They show an enormous increase during the latter half of the century of the productive power of the people of this country, and they prove, moreover, that no other nations possess equal producing power *per capita*. By the figures which he has tabulated, Mr. Mulhall shows that from 1820 to 1890 the "foot-ton" power of the United States increased from 4,292,000,000 foot-tons daily to 129,306,000,000 foot-tons. A foot-ton is a method that statisticians have of measuring the producing powers of a country. It signifies the ability of a man to accomplish, with ordinary exertion in ten hours, an amount of work equal to raising 300 tons 1 foot high. In 1820, the forces at the command of the Americans were equal to 446 foot-tons of power *per capita* of the population. By 1890, the productive forces had increased to 1,940 foot-tons *per capita*. These forces are now busily engaged in developing the resources of the country, in cultivating the soil, working the mines, operating the industries, carrying on the commerce, or in looking after the development of the mental powers and the enlightenment of the people, whereby their producing powers may be still further increased.

Next to America in the scale comes Great Britain, the producing power of which is 1,470 foot-tons to the inhabitant daily. Germany's forces amount to 902 foot-tons for each person daily; those of France to 910 foot-tons; those of Spain to 590 foot-tons; those of Austria to 560 foot-tons, and those of Italy to 380 foot-tons.

† Thomas Carlyle, in his essay on Labor, said: "The latest gospel in the world is, Know thy work and do it; * * * for labor is life; from the inmost heart of the worker rises this God-given force. * * * Knowledge, that will hold good in working, cleave thou to that, for Nature herself accredits that, says 'Yea' to that. Properly thou hast no other knowledge but what thou hast got by working; the rest is all a hypothesis of knowledge—a thing to be argued of in schools, a thing floating in the clouds, in endless logic vortices, 'till we try it and fix it.'"

The organisation through the aid of capital of large industrial operations, superseding former small independent industries, is a frequent source of lamentation on the part of well-meaning philanthropists and others, on the theory that the small merchant has been injured thereby. This is probably true in isolated instances, but the evidence that the wage-earner (the subject of our discussion) has been benefited by improved regulations, superior factory buildings, and amelioration of exhausting toil under modern methods, is overwhelming.

Moreover, the employment of large capital and improved machinery has enormously increased production and decreased cost to the consumer. Wages are higher and cost of living is lower than formerly. The average wage-earner in America lives to-day in a manner quite superior to the small manufacturer of former days. The large factories employ armies of skilled operatives, many of whom would be incompetent to conduct even small industries successfully. They are reasonably assured of a fixed income, and are often enabled, by saving a portion of their wages, to become small capitalists themselves. Capital is, after all, nothing more than the aggregate savings of labor. The great financial operations are conducted by the aid of these savings of the masses, otherwise the thrifty workingman could receive no interest on his deposit in the savings' bank. The individual millionaire is a much less important factor in the world's work than the socialistic agitator would have us believe.

The "good old times" are hallowed in our recollections and in our traditions; but when subjected to critical comparison with the improved civilisation of modern times, we find, I think, that the masses have gained immeasurably in all the comforts and conveniences of life, in social position, in political power, in freedom from care, in health and happiness.

The coming conflict between proletariat and plutocrat is a favorite theme with socialistic writers. According to these, wealth is *per se* criminal, and its chief employment the oppression of the poor. I claim that modern experience

proves the antithesis of this statement, which selects exceptional instances of financial crimes and attempts to use these as a blanket with which to smother all the good deeds and grand undertakings in which capital is ever engaging. Patriotic sentiment also protests against such statements. The aid of capital has been the means, within little more than a century, of raising the United States of America from the condition of an insignificant agricultural colony, which was not permitted under monarchical rule to manufacture the simplest articles for home consumption, into the greatest workshop of the world, and has placed it in the front rank of wealth and power among nations.*

Capital has stimulated the inventive faculty of the people and thereby aided the operative, in many instances, to emerge from the condition of the laborer into that of the capitalist. Very many, perhaps a majority of employers in this country, are men who have risen from the ranks of labor.

The reckless denunciation of wealth by foreign socialistic agitators is the chief danger confronting the industrial class in America to-day, since it tends to retard investment of capital in industrial enterprises, and thus to restrict the employment of labor. It is far easier for the agitator to "kill the goose that lays the golden egg" than it is for the mischief-maker to turn his hand to honest labor. The free soil of America is not adapted to the growth of such

* The first spinning jenny ever seen in America was secretly imported from England and exhibited in Philadelphia in 1775. In 1774, the British Parliament enacted stringent laws prohibiting the exportation to America of textile machinery. It was provided (by 21 George III, Chap. 37) that "any person who packed or put on board, or caused to be brought to any place in order to be put on any vessel for exportation, any machine, engine, tool, press, paper, utensil, or silk manufacture of the kingdom, or goods wherein wool, cotton, linen or silk are used, or any model or plan of such machinery, tool, engine, press, utensil or implement, should forfeit every such machine, etc., and all goods packed therewith, and £200, and suffer imprisonment for one year." In 1782, a law was enacted which prohibited, under penalty of £500, the exportation or attempt to export "blocks, plates, engines, tools or utensils used in, or which are proper for, the preparing or finishing of calico, muslin, etc." The same act prohibited transportation of tools employed in iron and steel manufactures.—U. S. Tenth Census, Vol. II, p. 537.

noxious weeds, and the sooner such pernicious doctrines are eradicated, the sooner will our industrial population reap the rewards to be gained in the returning prosperity for which it has so long and patiently waited.

APPENDIX.

The Cost and Danger of Strikes.—Few persons are aware of the enormous annual loss of wages due to strikes. Startling figures are furnished by the Labor Bureau at Washington in a recent publication, covering the period from 1881 to 1894, inclusive.

It appears that no less than 3,714,406 persons were thrown out of employment, suffering a loss in wages of $163,807,866. Fifty-five and one-half per cent. of the strikes failed entirely; 32 per cent. are classed as successful, and 12½ per cent. as doubtful, or partly successful. Labor organisations contributed $10,914,406 to assist strikers.

The promoters of strikes argue to their comrades that unsuccessful efforts are, nevertheless, ultimately beneficial; but study of the subject has led me to take the opposite view, viz.: that all strikes of skilled workmen are, in the end, harmful to the participants. No one single cause has done more, in my opinion, to hasten the introduction of entirely automatic machinery in operations where a certain degree of skilled labor was considered indispensable, than strikes on the part of such skilled employés. Numerous instances might be recalled where large manufacturers have, on account of strikes, cheerfully expended immense sums of money in perfecting automatic machinery, not primarily to effect economy in wages, but as an insurance against future danger from such causes.

A notable instance of this nature occurred a few years ago at one of the largest iron and steel works in the world. In a certain department, specially skilled men were able to make wages which now seem incredible; they were, however, paid a percentage upon the tonnage, and, owing to enormous output, the profits of these operatives exceeded in some years that of many successful manufacturers having large capital at stake. These men considered them-

selves indispensable, and struck—not for higher wages or shorter hours—but at the dictation of outsiders. When work was resumed, they found their occupation gone forever; automatic machinery had supplanted the former skilled labor.

I do not believe that any employé (I myself am one) is indispensable, and many highly skilled and otherwise valuable operatives have, unfortunately for themselves, failed to appreciate this fact until too late.

The danger I have indicated regarding the effect upon skilled labor of strikes, does not appear to have presented itself to the minds of the workingmen; and if their leaders have perceived it, they have concealed it. I regard the strike as a barbaric weapon of attack, resembling somewhat the boomerang, which, we are told, frequently returns and injures its projector.

Another element of danger to the workingman, which usually accompanies a strike, is the license which it affords to the irresponsible and lawless element of society to commit depredations, endangering the lives and property of innocent persons, and sometimes compelling the use of armed force for its suppression. The strikers, though innocent of these overt acts, are injured thereby, and the suspicion lurking in many minds is not without foundation, that some leaders of strikes, while openly exhorting their followers to preserve the peace, secretly count upon this outside aid; and, if they do not, they are strangely blind to the result of past experience.

The Eight-Hour Agitation.—This is the fundamental principle or philosophy of the trades-union movement in this country, and, in 1888, the American Federation of Labor, numerically one of the strongest of the unions, voted to unite with the Eight-Hour League, and thenceforth to concentrate all effort on the struggle for eight hours. Their program was then to take charge of one trade at a time. Thus, in 1890, the gauge of battle fell to the lot of the carpenters, who accordingly struck, under orders, for an eight-hour day on May 1st, and won temporary victories in 137 cities. Plans were laid for the miners to strike on May 1,

1891, for eight hours, but the conditions were not then favorable; and, although these plans have since been in abeyance, owing to depressed conditions of trade, they have not been abandoned, and I have reason to believe that employers in almost all trades will be called upon to meet this question in the not very distant future.

The argument of the eight-hour philosophers is that, by restricting the hours of work, more laborers must be employed and the idle surplus provided for. I consider that this is specious reasoning. The overflowing stream of immigration from European countries, attracted to America by comparatively high wages, suffices even now to produce a permanent flood, at least in the fields of unskilled labor. If to this we add the still more powerful attraction of a legal working day of eight hours, the tidal wave flowing from all the less-favored countries in the world would swamp our native industrial population, and induce a condition which would be far less favorable to them than that which now obtains.*

* I am able to substantiate these views by figures bearing upon the subject. The official statistician of Paris, M. Bertillon, gives the proportion of foreigners in that city as 7·5 per cent.; these are chiefly wealthy persons who distribute a portion of their funds among the tradespeople. London and Vienna have each 2·2 per cent. Berlin has 1·1 per cent. of foreigners, also mainly persons of wealth.

The foreigners residing in American cities are chiefly poor immigrants, who compete with the native working class for wages, and are accustomed and content to live in comparative squalor. The percentages of "foreign-born" to total population in five principal American cities are as follows: Philadelphia, 25·74 per cent.; Boston, 35·27 per cent.; New York, 42·23 per cent.; Chicago, 40·98 per cent.; Milwaukee, 38·92 per cent. More than 30 per cent. of the foreign-born males, 21 years of age and over, in the five cities named, are aliens. The percentages of "persons of foreign parentage" to total population in these cities are as follows: Philadelphia, 56·58 per cent.; Boston, 67·96 per cent.; Chicago, 77·90 per cent.; New York, 80·46 per cent.; Milwaukee, 86·36 per cent. This information was courteously furnished by the Chief of the Census Division, Department of the Interior, Washington, March 12, 1896.

More rigid enforcement of contract labor laws has decrease[illegible]tation of foreign labor under direct or written contract, but there is ample evidence that Italian labor purveyors still influence such immigration. Immigrant Inspectors Birmingham and Hinkle reported (under date of January 11, 1895) to the Secretary of the Immigration Investigation Committee, among other

The eight-hour party has succeeded, through political influence, in making eight hours a legal working day in governmental employment, and largely also in municipal contracts, and violators of the law have been rigorously prosecuted. A remarkable case occurred in Buffalo, which worked great hardship upon a citizen, and led to the decision of Justice White, of the Superior Court at Buffalo, declaring the eight-hour law unconstitutional. Justice White's decision was based upon the clause of the Constitution which provides that "no person shall be deprived of life, liberty or property without due process of law." That provision of the Constitution has been construed to mean that the rights and privileges of a citizen to make contracts relating to his business or property cannot be interfered with by legislation. It has

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facts, as follows: "Mr. Desabadia (an Italian padrone of New York) informed us that he was regularly engaged in supplying Italian laborers, in any numbers, to contractors or others desiring labor done; that he was prepared now to furnish from 200 to 600 men (Italians) for work of any nature; that he could furnish stone-masons, carpenters or men of almost any of the building operations."

The equivalent of the padrone system is not confined to Italians. Poles, Hungarians, Greeks, and other foreigners, temporarily camping in this country, are forwarded, "on call," wherever large operations are in progress, crowding out American labor by accepting lower wages. In Texas and other border States, invasions of Mexicans occur at regular intervals, especially at sheep-shearing time; these people contribute nothing to the wealth of the country, and patronise the railways by walking home on the ties!

An investigation made by the Senate Committee on Immigration in 1893 (Senator Hill, chairman) developed the startling fact that Italian bankers remitted to Italy from New York City alone $25,000,000 to $30,000,000 a year, largely savings of "Dago" laborers, and a marked increase in wealth in certain sections of Italy has been traced directly to money earned in the United States by these "birds of passage." Italians who have become domiciled here for a few years are beginning to make incursions into skilled labor fields where formerly they were unknown, and where even a suggestion of the kind would have been ridiculed. In the shoe trade, for example, it is said that large numbers of Italians have been substituted for American workmen who went out on strike some time ago.

The facts stated in these various foot notes have been gathered by the writer at different times during several years from a variety of independent sources, and it is only when placed in juxtaposition that their true significance becomes apparent. These illustrations are but a few samples of facts at hand that are too numerous to mention, and they present practical problems for legislators and workers, of far more importance than any theoretical discussions.

been declared by the courts that liberty, in its broad sense, as understood in this country, means the right not only of freedom from actual imprisonment, but the right of one to use his faculties in all lawful ways, to live and work where he will, to earn his livelihood in any lawful calling, and to pursue any lawful trade or vocation. All laws, therefore, which impair or trammel these rights, which limit one in his choice of a trade or profession, or confine him to work or live in a specified locality, or exclude him from his own house, or restrain his otherwise lawful movements, except where the public health or safety intervenes, are infringements upon his fundamental rights of liberty, which are under constitutional protection.*—People *vs.* Warren, 34 N. Y. Supp., Superior Court, Buffalo, 942.

The impossibility of regulating the rate and hours of labor by legislation, unless in the exercise of the police power, or law of public health and safety, was recognised years ago by Chief Justice Ruger, in McCarthy *vs.* Mayor,

*"Henry J. Warren, superintendent of the Barber Asphalt Company, was convicted by a police court in Buffalo of a misdemeanor for a violation of this (eight-hour) section of the Buffalo charter, and punished by imprisonment. From his conviction he appealed to the Court of Sessions and to the General Term of the Supreme Court, where the conviction was affirmed, the courts holding the act constitutional and the conviction valid. As Warren could not by law appeal to the Court of Appeals in that case, he sued out a writ of *habeas corpus* in the Supreme Court, to test the questions affecting the validity of the conviction, and to inquire by what authority he was restrained of his liberty. This proceeding is a good illustration of the efficacy of the ancient writ of *habeas corpus*, for, although the Special and General Terms of the Supreme Court dismissed the writ, and again declared the prohibitory statute constitutional and the accused properly convicted, yet, upon an appeal to the Court of Appeals, the decisions of the lower courts were reversed, and the arrest, trial and conviction declared without jurisdiction and void.

"After this long and tedious fight Warren was released, only to be arrested again for a violation of the eight hour law, this time for employing an alien Italian laborer. He was indicted by the grand jury, and convicted in the Superior Court at Buffalo. His counsel contended that the act in question, so far as it seemed to prohibit the employment of alien laborers upon public works, was repugnant to the Federal and State Constitutions and to the treaty between the United States and Italy. Upon an appeal to the General Term of the Superior Court, the act, so far as relates to the employment of aliens, was declared unconstitutional, and Warren was discharged."—People *vs.* Warren, 77 Hun., 120; People *ex rel.*, Warren *vs.* Sheriff, 144 N. Y., 225.

who said in reference to the original eight-hour law then under discussion:

"It is well to premise that this act was not intended to affect or regulate the rate of wages which should govern as between employer and employé. That subject is left by the act, as it always must remain, open, to be fixed by the agreement of the parties intending to enter into those relations. Experience has shown that legislation on the subject must always be futile and ineffectual, for the reason that it is controlled by the natural laws determining the value of labor and property, and which are as much beyond the power of statutes to affect as they are above the control of the wishes of the parties interested therein."

I do not mean to imply from the foregoing statements that I am opposed to shorter hours for labor; on the contrary, I believe that a shorter working day, wherever it is practicable, is beneficial alike to employé and employer; but under present conditions, it appears to me, after a careful survey of the field, that there are some prominent obstructions which must be removed before an eight-hour day can be universally adopted, or before the operatives who now work ten hours a day can reasonably hope for a general reduction to eight hours without a corresponding reduction of wages.

Wise men usually count the cost of any new undertaking before embarking in it, and a very simple calculation will show surprising figures as to the additional cost of manufacture should employers be called upon to pay the same wage for eight hours' that they now pay for ten hours' work. If we assume that an establishment employs a thousand hands (there are factories having capacity for four or five times this number), a reduction of two hours per day per man would mean an aggregate of two thousand hours' reduction per day in the shop. Assuming the average wage to be 10 cents an hour (this is much below the true average), the additional cost for this item alone would be $200 per day; while the loss from decreased output and increased fixed charges, rate of interest on plant, etc., per unit of product, would, I believe, extinguish any margin of profit

obtained under present prices in any manufactured article where competition is keen. It is, of course, possible that in those occupations in which the output depends more upon manual dexterity than upon the mere tending of automatic machinery a decrease of working hours may be partly offset by an increase of effort; but this would, I think, prove an exception, the effect of which is, in part at least, discounted by the low figure selected to represent average wages.

It is apparent that a rearrangement of some kind would be necessary; is it not likely that this rearrangement would be found in a corresponding reduction of wages?

Sympathising as I do with all legitimate efforts of workingmen to better their condition, it appears to me that the aim of their organisations should be to secure a reduction in the hours of those workers who are now compelled to submit to clearly excessive consecutive hours of attention to duty—conditions that are not only deleterious to the welfare and happiness of the laborer himself, but in some instances increasing the danger to life and limb of others, whose interest and sympathy would be a powerful lever, if properly applied, to help to remove this incubus resting at present upon the boasted freedom of labor in this country.

If the views which I have here advanced shall have the effect of tending, on the one hand, to discourage the unwise and impracticable schemes of some misguided wage-workers, and, on the other hand, to stimulate keener and more general interest on the part of employers of labor in the welfare of their operatives, and thus to foster a closer union between these two great interdependent elements of society, I shall feel that my efforts have been repaid. The nature of my occupation for the past fifteen years has perhaps afforded unusually favorable opportunities for viewing both sides of the sociological questions here discussed; it has certainly aroused keen personal interest in the subject and has stimulated study of these problems.

THE ELECTRO-METALLURGY OF ALUMINIUM.*

BY DR. JOSEPH W. RICHARDS, A.C., Lecturer on Electro-Metallurgy at the Lehigh University.

Metallurgy is the art of extracting metals from their ores, and of refining them to the purity required for their use in the metal industries.

Electro-metallurgy is that branch or division of the metallurgic art which concerns the use of electricity as an adjunct to, or a substitute for, the ordinary methods of extracting metals from their ores or refining crude metal. Electrical methods may enter into metallurgical operations in three stages, viz.:

(A) Electrical refining of crude metal which has been produced from the ore by non-electric methods.

(B) Electrical reduction or production of crude metal from the ore, which is afterwards refined by non-electric methods.

(C) Electrical reduction and refining, or the entire substitution of electric for non-electric methods. The operations of reduction and refining may take place together, in one operation, or be effected consecutively, independently of each other.

The electrical methods used in metallurgy may be classed, as to their character, under three heads, viz.:

I. Electrolysis of aqueous solutions.

II. Electrolysis of fused electrolytes.

III. Electric smelting, or electro-thermal operations.

Considering these operations in order, I will enumerate the kind of metallurgical operation for which each is capable of being used.

I. Electrolysis of aqueous solutions may be used for:

(1) Refining crude metal, using it as soluble anodes in the solution of a salt of the same metal.

* A lecture delivered before the Franklin Institute, January 24, 1896.

(2) Extracting metals *directly* from their ores by using the ores themselves in the form of soluble anodes, in the solution of a salt of the same metal.

(3) Extracting metals *indirectly* from their ores by

a. Producing from the ore by some other means, chemical or electrical, a compound which can be used as a soluble anode, as in the former division. This method is especially applicable when the ore itself is unfit for use as a soluble anode.

b. Treating the ore chemically so as to convert it into a soluble salt; dissolving this in water, and precipitating the metal by electrolysis, using either insoluble anodes, or soluble anodes of a cheaper metal placed within porous cells.

II. Electrolysis of fused compounds may be applied to:

(1) Refining crude metal, using a fused salt of the same metal. This method is of very limited application.

(2) Extracting metals *directly* from their ores. This is applicable only when the ore itself is an easily fusible compound, in which case it is melted and electrolysed, using either an insoluble anode, or one which will combine with the non-metallic ingredient of the ore and form an inert compound.

(3) Extracting metals *indirectly* from their ores by:

a. Converting the ore into some suitable fusible compound, and then electrolysing this, as above.

b. Dissolving the ore in some fused salt which acts as a solvent for the ore, and which requires a higher electromotive force to decompose it, in which case a current of properly regulated potential will decompose the ore without affecting the fused salt which acts as its solvent. Either soluble or insoluble anodes may be used, as in (2).

III. Electric smelting or electro-thermal methods are those in which the apparatus is arranged so as to convert the electric energy as largely as possible into heat, the heat thus developed being utilised to effect chemical reactions or reductions. The ore, in contact with the substance or substances necessary to reduce it, is so placed in the appa-

ratus as to be subjected to the electrical heating, and is thereby reduced. Frequently the carbon used in the apparatus to convey the electric current serves as the reducing agent, as in reducing ores containing oxygen.

Electric smelting may be applied to:

(1) Extracting metals in a crude state *directly* from their ores.

(2) Extracting metals in a pure state from the purified ore, or from a pure compound of the metal prepared from the ore.

It is sometimes difficult to draw the line precisely between Classes II and III, because of the fact that, during the electrolysis of a fused salt, there is necessarily developed by the electric current an amount of heat proportioned to the conduction-resistance of the fused salt; and when the amount of current used for electrolysis is very large in relation to the size of the bath, the development of resistance heat may become so large as to keep the bath fused without the application of heat from an external source, and the process would then seem to have passed into the class of electric smelting processes. Such, however, I should not consider to be the case, because the electric heating, rendering the apparatus independent of external heating, is, in this case, only an incident to the process; the principle of the method does not depend on it at all. The electrical decomposition of fused salts is, therefore, to be distinguished by the low resistance of the bath, the low potential required to operate it, and the presence of those arrangements necessary for economical electrolysis. The temperatures attained in electric smelting furnaces are generally very high, reaching to nearly 4,000° C. (7,000° F.), and under such conditions chemical reactions are effected which are impossible in any other form of furnace.

With this introduction, let us consider

THE ELECTRO-METALLURGY OF ALUMINIUM.

The native minerals which may be considered as the available ores of aluminium are as follows:

Bauxite.—Impure hydrated oxide of aluminium, carrying

usually some ferric oxide, silica and titanic oxide. It is insoluble in water, easily soluble in strong acids after being calcined; infusible, except in the electric furnace, and then practically a non-conductor of electricity. Soluble in certain fused fluoride salts, particularly the double fluorides of aluminium and the alkali metals. The resulting bath is a good electrolyte.

Cryolite.—Double fluoride of aluminium and sodium, usually impregnated with some silica. Insoluble in water, easily fusible at a bright-red heat, and then a good conductor of electricity, which liberates aluminium and fluorine (very irritating fumes).

Native Alums.—Included under this general head are the native sulphate of aluminium, or double sulphates of aluminium and the alkalies. Soluble in water; the acid of the aluminium sulphate driven off by gentle heating, leaving either an infusible residue of alumina or a pasty mixture of alumina and alkaline sulphate, from which the latter can be removed by washing.

Kaolin.—The pure, white china clay. A hydrated silicate of aluminium. Is found in immense quantity and very pure. Insoluble in water, infusible, except in the electric furnace; unattacked by acids, except sulphuric acid, which dissolves out the alumina and leaves the silica; and by hydrofluoric acid, which removes the silica and leaves aluminium fluoride.

The chemical compounds of aluminium which may be considered available for use in electric processes, and which may be formed by chemical processes from the ores and then used as the intermediate products mentioned in our classification, are briefly as follows:

Aluminium Chloride.—Formed by an expensive operation from alumina. Attracts moisture strongly from the air, easily soluble in water (the aqueous solution may be made by dissolving alumina in acids). Fusible easily, but fumes in the air and volatilises at a temperature close to that of its melting point. The fused salt conducts electricity very poorly.

Aluminium Chloride with Alkaline Chloride.—Formed in the

same manner as the simple chloride, alkaline chloride being added in the process. Easily soluble in water, only slightly deliquescent, easily fusible, and the fused salt a good electrolyte. Much easier to work with and handle than the simple chloride.

Aluminium Fluoride.—Can be made cheaply from the ores. Nearly insoluble in water, infusible, volatilises at a high temperature, soluble in many fused salts, and the resulting bath a good electrolyte.

Aluminium Fluoride with Alkaline or Alkaline-Earth Fluorides.—Insoluble in water, easily fusible salts, good conductors of electricity, dissolve alumina freely, and allow of *its* electrolysis without being themselves decomposed.

Alkaline Aluminates.—Soluble compounds of alumina and potassa or soda. Fusible with difficulty and decomposed by the current into alkali metal, aluminium and oxygen. Electrolysis unsatisfactory. Made by heating together alumina and the alkali; or, in solution, by dissolving alumina in solution of caustic alkali.

Metallic Aluminates.—Difficultly fusible compounds, troublesome to make and mostly insoluble in water; scarcely available in any electric method, excepting, possibly, in the electric furnace.

Aluminium Phosphate.—Insoluble in water, nearly infusible and very difficult to decompose.

Aluminium Borate.—Difficultly soluble in water, easily fusible, and when fused, a good electrolyte. Made by dissolving alumina in boric acid or borax. The current, however, liberates boron also.

Aluminium Nitrate and Acetate.—Soluble salts formed by dissolving alumina in the corresponding acids. Decomposed by gentle heating, leaving alumina.

Aluminium Sulphide.—A difficultly-fusible compound; attracts moisture, reacts on water, setting free hydrogen sulphide and leaving alumina. Made only with difficulty, by passing carbon bisulphide vapor over red-hot alumina. Hardly suitable for any electrical process.

Aluminium Sulphide with Alkaline Sulphides.—Easily fusible salts, made with comparative ease by melting together

alumina, carbon, sulphur and an alkali. Stable in the air, insoluble in water, and when fused, good conductors and easily decomposed by the current into aluminium and sulphur.

Before taking up in detail the different kinds of electric processes, allow me to make a few remarks on the properties of aluminium itself.

Aluminium melts at 625° C.—a dull-red heat. It volatilises slowly at the temperature of the electric furnace. In mass, it is very slightly affected by air or water, but when finely divided, burns rapidly in air and oxidises rapidly in water. Easily soluble in solutions of caustic alkalies and in hydrochloric acid; very slowly attacked by sulphuric, nitric or hydrofluoric acid. Conductivity for heat and electricity about one-half that of silver. Specific gravity, 2·7; when melted, 2·5, causing some difficulty in working fused baths. Rapidly attacked by melted silicates, borates or any salts which it can decompose. Its atomic weight is 27, its chemical equivalent 9. Its electro-chemical equivalent, therefore, is 0·00009315; that is, an electric current of 1 ampère will set free by electrolysis, from any aluminium compound capable of electrolysis, 0·00009315 grams of aluminium per second, or slightly over one-third gram per hour, or 8 grams (= ¼ ounce) per twenty-four hours.

The minimum voltage necessary to decompose the aluminium compounds, whose heats of formation are known, is as follows:

	Volts.
Aluminium fluoride	4·0
" oxide	2·8
" chloride	2·3
" bromide	1·7
" iodide	1·0
" sulphide	0·9

We will now proceed to consider the electric processes according to the preceding classification.

I. Electrolysis of Aqueous Solutions.

(1) Refining of crude metal.

The question of thus refining impure aluminium to a high standard of purity is one to which very little attention

has thus far been given. Since the solution of metal at the anode balances the deposition of metal at the cathode, no voltage is absorbed in electric decomposition; potential is needed only to overcome the conduction-resistance of the electrolyte, and the water need not, therefore, be decomposed. The difficulty is to deposit the molecules of aluminium upon the cathode more rapidly than such finely divided particles can be oxidised by the water, otherwise the deposit is entirely changed to alumina. This difficulty is met by using a current of large quantity per unit of depositing surface. I give below the results of an experiment made by myself several years ago:

Solution.—A strong solution of aluminium chloride *plus* 10 per cent. of sodium acetate.

Voltage.—0·9 volts across the electrodes.

Resistance.—Of battery and wires . . . . . 0·7 ohms.
Of solution . . . . . 1·55 "
Specific resistance of the solution . . . . . 20· "

Current.—0·4 ampères, giving a current density of 290 ampères per square meter of cathode.

Results.—A liberal evolution of gas at the cathode, apparent attack of the anode (impure aluminium) and, in fifteen minutes, a bright metallic deposit of aluminium on the cathode.

I have quoted this experiment simply to prove the possibility of thus refining impure aluminium, and it is within the range of possibility that at some future time we may see impure aluminium being refined on these lines, just as copper is now treated.

To a Philadelphia audience the chief interest in this part of my subject will probably be concerned with the aluminium plating on the tower of the Public Buildings. This plating is deposited from aqueous solution, using soluble aluminium electrodes, but it is important to state that the bath used contains a tin salt as well as an aluminium salt. The deposit is, therefore, a mixture, or possibly an alloy, of aluminium and tin, which is much easier to deposit than pure aluminium, as the tin protects the particles of aluminium from oxidation during deposition. This method of procedure, therefore, is not applicable to the metallurgical purpose of obtaining *pure* aluminium from crude metal.

(2) Imagine an ore of aluminium in place of the soluble aluminium anodes, in the case I (1), and we have case I (2). No successful process has yet been developed on these lines, but it is not out of the range of possibility. The ores of aluminium are all non-conductors, but imagine them mixed in with the substance of a carbon anode, let us say, so that the composite anode, on being attacked by the liberated acid ingredient of the electrolyte, reforms the aluminium salt which was decomposed, and thus regenerates the solution. The voltage required for decomposition, in this case, would be practically that required to decompose the aluminium compound in the anode, and, if this compound were an oxygen compound of aluminium, would require 2·8 volts, thus entailing the simultaneous decomposition of the water (which requires 1·49 volts), and corresponding loss of power. While such processes would be very difficult to manage practically, they are, nevertheless, theoretically possible.

(3*a*) The previous case would be much simplified, if instead of the ore we could find some aluminium compound made from the ores which would be a good conductor of electricity, and could, therefore, act alone as an anode; and, particularly, if we could find one such requiring less than 1·49 volts to decompose it. I am not prepared to name such a compound, for I do not know of one; perhaps the double alkaline sulphides come the nearest of any with which we are at present acquainted. The voltage required for such salts is only 0·9, and they may possibly be conductors to some extent and stable in water. Our information on the properties of these salts is, I regret to say, very meager.

(3*b*) Aluminium ore can easily be converted into soluble salts, but it is practically out of the question to decompose such solutions with the use of *insoluble* anodes, for the reason that the voltage required for decomposition alone would, in any possible case, reach several volts, and metal could only be obtained by using very concentrated solutions, current of great density, and high voltage (and consequent great loss of power) in the process. However, using soluble anodes of another cheaper metal, placed in porous cells to

prevent their salts from mixing with the aluminium salt around the cathode, the case is changed. The voltage required for decomposition in this case is only the *difference* between that required to decompose the aluminium salt, and that which would be required to decompose the corresponding salt of the other metal, which latter voltage represents the counter-electromotive force obtained by the solution of the anode. This difference of voltage, representing the voltage necessary for decomposition, would have the following values when the soluble anodes were the metals designated:

	Volts.
Zinc	0·22
Iron	0·55
Tin	0·58
Lead	0·54

If, therefore, the refining of impure aluminium in aqueous solution could be effected satisfactorily, it would apparently not be a very difficult step to extract the aluminium directly from a solution of its salt, using zinc or possibly iron for the soluble anode, and keeping the zinc or iron salt apart from the aluminium salt by a porous partition. Theory indicates such a process as being within the range of possibility.

II. Electrolysis of Fused Compounds.

(1) Refining of crude metal.

It is quite conceivable that by the use of some of the good-conducting double chlorides or double fluorides of aluminium and the alkaline metals, which melt below the fusing point of aluminium, the refining of crude aluminium, using it as the anodes, might be practised successfully; but I do not know that such an experiment has ever been made. This direction appears to me to offer great inducements for experimental work, since, by the present methods of extraction, impure aluminium can be produced direct from the ores at nearly 10 cents per pound less than pure metal. With so large a margin for profit, therefore, a suitable refining process should find a place in the industry.

(2) The only fusible ore of aluminium available for direct electrolysis is *cryolite*. If melted and electrolysed with an insoluble anode, aluminium is separated and fluorine set free (which acts on the carbon anode, forming carbon fluoride, a very disagreeable gas), while the composition of the bath is gradually changed by the elimination of aluminium fluoride, leaving it relatively richer in sodium fluoride, until at last sodium is set free and the bath practically stops working. This method of working cannot be practised commercially for several very evident reasons. Dr. Kleiner, of Zurich, tried, in 1887, to keep the bath constant by lining the decomposing vessel with bauxite, hoping that the evolved fluorine would attack and thus re-form aluminium fluoride. The regeneration, however, was very imperfect. No substance is known which, when used as an anode in electrolysing cryolite, will unite with the liberated fluorine and render it inert. This class of processes, based on the direct decomposition of cryolite, may be said to be practically inoperative, and to offer very little, if any, inducement to the investigator.

(3*a*) Converting the ore into some suitable fusible compound, and then electrolysing. This heading brings us at once to the original process by which Deville and Bunsen, in 1854, first made aluminium *en masse*. Wöhler had isolated aluminium in 1827, by decomposing aluminium chloride with metallic potassium. Bunsen had isolated magnesium by electrolysing fused magnesium chloride, and shortly after, both Deville and Bunsen, independently of each other, treated aluminium-sodium double chloride in the same way, and obtained the aluminium in considerable quantity. This salt, which melts at about 185° C., was contained in a glazed porcelain crucible, and electrolysed by the current of a primary battery, with a cathode of sheet platinum and an anode of carbon, two Bunsen cells in series (giving 3·6 volts) being found capable of decomposing the bath. As the bath is decomposed, fresh salt is fed in, and chlorine is continually evolved, while sodium chloride accumulates in the bath and finally stops the operation. Had Deville had dynamos at his command, even this imperfect process might

have been developed by him into a cheaper method than his sodium process.

Quite recently, the idea has been advanced of converting the ore into the fusible double sulphide of aluminium and an alkali metal, and electrolysing this compound. The great advantages of this salt over the double chloride are, that it is much more cheaply prepared, is very stable in the air and requires less than 1 volt to decompose it. The journals have reported that the process has been worked at the Rhine Falls, Switzerland, but I can obtain no authoritative confirmation of that statement.

I know of no other fusible aluminium salt available for this direct electrolysis, although it is within the range of

FREDERICK WÖHLER,
Discoverer of Aluminium,
1827.

H. ST. CLAIRE DEVILLE,
Founder of the Aluminium
Industry, 1854.

possibility, and even of probability, that others will be discovered and, perhaps, made available in the industry.

(3*b*) Dissolving the ore in a fused salt which acts as a solvent, and then electrolysing. This division of electro-metallurgic processes contains the only methods by which commercial aluminium is at present being produced. The application of this principle to the production of aluminium was made independently, in the year 1886, by Héroult, in Europe, and by Hall, in America. The latter worked out the idea in commercial shape more quickly than his European rival, and was the first to put aluminium made on this principle on the market. This was in 1888.

In the process as at present practised, the solvent bath is composed of the double fluorides of aluminium and sodium. This bath may be simply cryolite, but preferably cryolite to which has been added a further proportion of aluminium fluoride and a little calcium fluoride (fluorspar). Into this bath is stirred pure alumina, made from ore by a chemical process, and which is dissolved by the bath to the extent of one-fifth of its weight. The electric current is then sent through this mixture, using for anodes carbon rods dipping into the bath from above. The cathode is formed by the carbon lining of the vessel, on the bottom of which the melted aluminium collects. When the dissolved alumina has nearly all been removed, the resistance of the bath rises, and fluorine fumes, from the decomposition of the solvent, begin to appear; fresh alumina is then stirred in, and the operation thus proceeds continuously. *Fig. 1** is a view of the interior of one of the pot rooms of the Pittsburgh Reduction Company, which works the Hall process. The pot is of boiler iron, having a thick lining of hard-baked carbon. It is made the negative electrode. The heavy copper bar above conveys the positive current, heavy carbon cylinders dipping into the fused material serving as the immediate positive electrodes, being connected with the copper bar by copper rods and cast-iron screw clamps. The whole is set on bricks, to ensure circulation of air, and thus to prevent the bottom from getting overheated. The boxes against the wall contain delicate voltmeters, which, by showing an increased potential absorbed by the pot, indicate at once to the workman the necessity of stirring in a fresh supply of alumina. *Fig. 2* is a sketch (not drawn to scale) of a vertical longitudinal section of one of these pots, with its several attachments. The several parts may be distinguished as follows:

S, iron shell; *N*, negative conductor; *L*, carbon lining, negative electrode; *P*, positive conductor; *A*, Screw clamps; *D*, copper rods; *C*, carbon cylinders, positive electrode; *F*, fused bath; *E*, cover of carbon dust.

* For the use of *Figs. 1* and *3* the *Journal* is indebted to the courtesy of *Cassier's Magazine*.

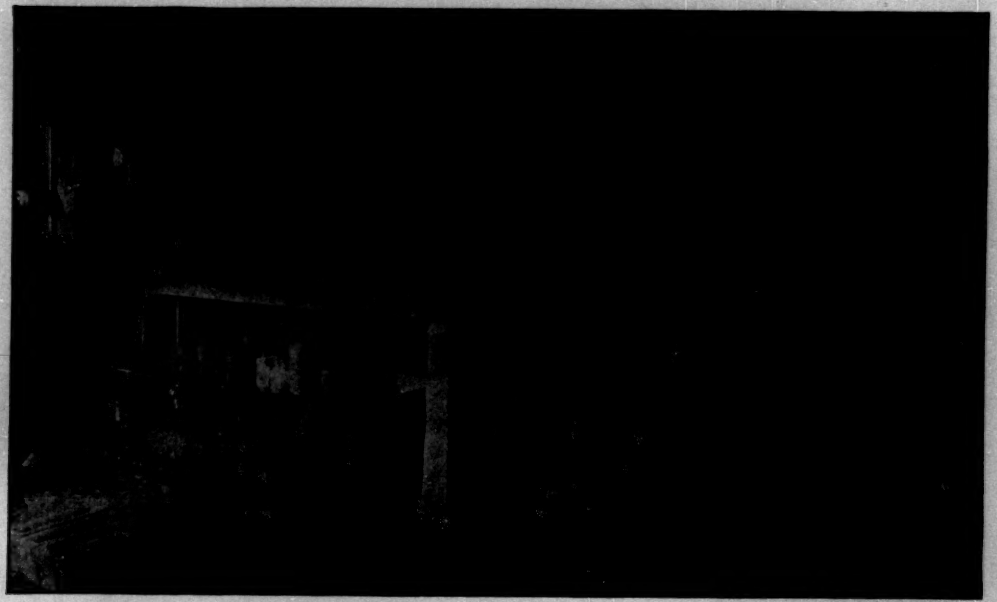

FIG. 1.—THE HALL ELECTROLYTIC PROCESS FOR ALUMINIUM. VIEW OF THE INTERIOR OF ONE OF THE POT-ROOMS OF THE PITTSBURGH REDUCTION COMPANY.

The cavity containing the fused salt has a sump in which the molten metal collects, and from which it is removed by ladles.

The ingredients present in the bath and the relative potentials necessary to decompose them are as follows:

	Volts.
Alumina	2·8
Aluminium fluoride	4·0
Sodium fluoride	4·7

The action of the current, when not of too high a voltage, is to decompose only the alumina, as long as it is pres-

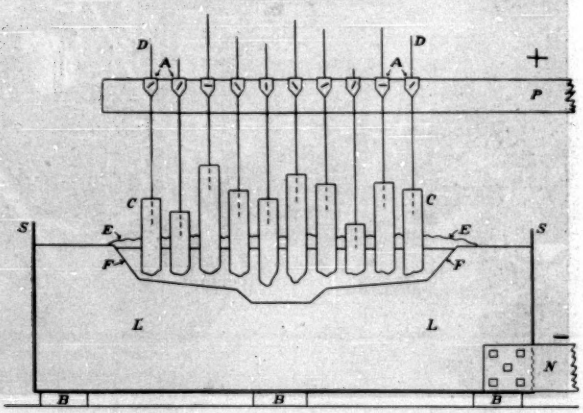

FIG. 2.—Vertical section of pot for operating the Hall process.

ent in the bath in sufficient amount. The oxygen simply combines with the carbon anodes and passes away as carbonic oxide.

We can calculate easily what the practical output is in such a process. Assuming that a pot absorbs on the average 6 volts, then we have a current of 1 ampère moved by a potential of 6 volts, equal to 6 watts of electrical work, capable, as we have before stated, of separating ¼ ounce of aluminium in twenty-four hours. But 746 watts constitute the electrical equivalent of an English

horse-power; therefore, 1 horse-power should be capable of separating

$$\frac{1}{4} \times \frac{746}{6} = 31{\cdot}5 \text{ ounces per 24 hours;}$$

and, if we assume an efficiency of 80 per cent. in the operation, we should still obtain 1¼ pounds of aluminium per day per electrical horse-power used.

FIG. 3.—Interior of engine and dynamo room in the plant at New Kensington, Pa.

The plants now engaged in making aluminium on this principle are the following:

The Pittsburgh Reduction Company's plant at New Kensington, Pa., on the Allegheny River, near Pittsburgh. This plant is run by steam-power, the coal used costing only 65 cents per ton; and, no doubt, is conducted as economically as any steam-power plant possibly could be, with our present means and knowledge.

Fig. 3 shows the interior of the engine and dynamo room, showing the new, six-pole, 600 horse-power Westinghouse

dynamos, and further off two dynamos of different type, driven by Westinghouse automatic engines.

The force employed at the Kensington plant is approximately 1,500 horse-power, and the output averages 2,000 pounds per day. At the same place the company has a rolling mill for making all sorts of plates, bars, beams and sheet,

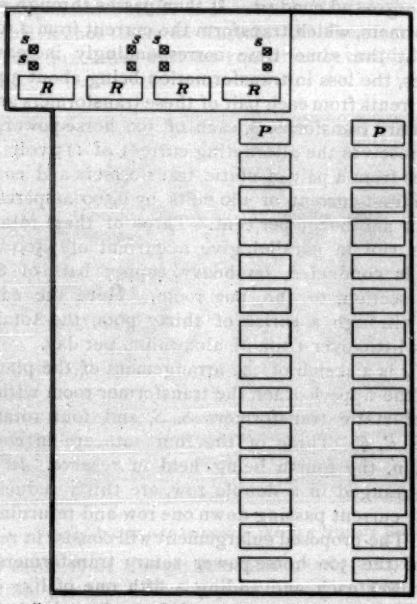

FIG. 4.—Sketch of plan of plant at Niagara Falls.

and is at present installing a new set of rolls driven by a 1,500 horse-power engine, which will be capable of rolling aluminium plates and sheets up to 8 feet in width. The purified alumina used by this company is partly imported from Germany and partly of domestic manufacture. The company also practically owns the largest of the Georgia bauxite deposits.

This company has had in operation, since July, 1895, a reduction plant at Niagara Falls. It is on the land of the Niagara Falls Power Company, a quarter of a mile above the new power-house. The alternating electric current of 2,500 volts potential and 500 ampères quantity (1,700 electric horse-power) is carried to the reduction works through an underground conduit. It then passes through six static transformers, which transform the current from 2,500 to 115 volts, at the same time correspondingly increasing the ampères, the loss in transformation being about 3 per cent. The currents from each pair of these transformers are passed into rotary transformers, each of 500 horse-power, each of which receives the alternating current of 115 volts by 3,600 ampères from a pair of static transformers and converts it into a direct current of 160 volts by 2,500 ampères, with a a loss of another 3 per cent. Three of these rotary transformers, run in parallel, give a current of 7,500 ampéres, which is conducted, on heavy copper bars of 8 square inches section, to the pot room. Here the current is passed through a series of thirty pots, the total output being a little over 1 ton of aluminium per day.

Fig. 4 is a sketch of the arrangement of the plant, showing, at the upper corner, the transformer room with its four pairs of static transformers *S*, *S*, and four rotary transformers *R*, *R*. Three of the four sets are in continuous operation, the fourth being held in reserve. In the pot room, arranged in a double row, are thirty reducing pots, *P*, *P*, the current passing down one row and returning up the other. The proposed enlargement will consist in rebuilding each of the 500 horse-power rotary transformers to 800 horse-power each, and adding a fifth one of like capacity. This will double the power, and the unoccupied half of the pot room will then be stocked with a duplicate set of pots. The capacity of the enlarged plant will be 2½ tons of aluminium per day.

The same company is also building a works on the land of the Hydraulic Power Company, of Niagara, close to the edge of the gorge, where it has contracted to take 4,500 horse-power. Six large dynamos of 750 horse-power each

are now being built for this plant by the Westinghouse Electric Company, and it is probable that they will be in operation at the close of this year.

Fig. 5 shows the type of dynamo which has been chosen for this new plant, and we may safely conclude that it represents the best modern type of machine for electrolytic work. In general outline it is very similar to the famous Oerlikon dynamos built at Zurich. At the new Niagara plant, these machines will be run directly coupled to the turbines.

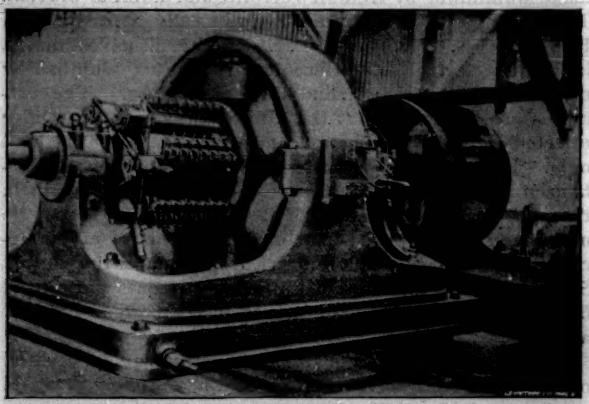

FIG. 5.—Type of dynamos to be used at the new Niagara Falls plant.

The capacity of this plant will be nearly 5,000 pounds of aluminium per day. The output of the plants of the Pittsburgh Reduction Company, now running, is, therefore, about 4,000 pounds per day, while the capacity of the works at the close of the present year, when the enlargements are completed, will be 11,000 pounds daily, or 2,000 tons per year. The officials and managers of this company deserve to be highly commended for the vigorous manner in which they have developed the industry.

In Switzerland, the works of the Aluminium Industrie

Actien-Gesellschaft, located at the Falls of the Rhine, have been in operation eight years, using the Héroult process. The company's present force is 4,000 horse-power, and its daily output 5,000 pounds of aluminium. For three years the company made only aluminium alloys with copper and iron, by Héroult's alloy process, which is described under the head of electric smelting. With the advent of cheap aluminium, the market for ready-made alloys almost disappeared, and the company, under the direction of the well-known electro-metallurgist, Dr. Martin Kiliani, began to make aluminium by Héroult's cryolite and alumina process. The principle of this process is practically identical with Hall's process. Hall says: "Melt cryolite, dissolve alumina in it, and electrolyse." Héroult says: "Flux alumina by melting cryolite with it, and then electrolyse." The processes are so similar that the United States Patent Office rejected Héroult's application, and issued the patent to Hall only. The practical operation of Héroult's process at Neuhausen is so similar to Hall's procedure, already described, that no further description of it is necessary. It may be mentioned here that the cost of all the items of raw material, labor and power is lower in Europe than in the United States, so that the present tariff of 10 cents per pound fairly represents only the difference in cost price here and abroad.

The Neuhausen Works are most picturesquely situated on the north bank of the Rhine, within a stone's throw of the famous Rhine Falls. The accompanying diagram, *Fig. 6*, shows the plan of the present works. The water has a fall of about 80 feet, and is delivered through two large pipes into a large main, from which it is distributed to the seven dynamos. The arrangement of these penstock tubes is not that which accords with the greatest economy of power, but the designers were hampered to a large extent by the situation of the plant, immediately beneath a bluff of rock. The diagram exhibits the old plant (shaded dark), which consists of a 300 horse-power turbine (third in the row), used since 1888; and two 600 horse-power turbines, in operation since 1891. The new plant (outlined) consists of four 600

horse-power turbines, used since 1893, and an extra one of the same power, since installed, which is held as a reserve. The large turbines are run by an upward current of water (Jonval type), the shaft being vertical (see *Fig.* 7).

The dynamos are on the floor above the turbines, and have as their shafts a continuation of the axle of the turbine. The armature is fixed to the shaft and revolves 150 turns per minute, while the field rings and poles are fixed. The brushes are accessible on the floor immediately above

FIG. 7.—Jonval turbines used at the Rhine Falls, Switzerland.

the turbine, while the field is on the floor above (*Fig.* 8). The whole construction passes through three floors or stages of the building.

Fig. 9 shows a nearer view of these admirable and neatly designed machines. Each generator gives a current of 7,500 ampères at a tension of 55 volts, and serves to operate a row of six pots. It appears that a greater voltage is used per pot than in our American practice. The cost of aluminium at these works is probably not over 25 cents per

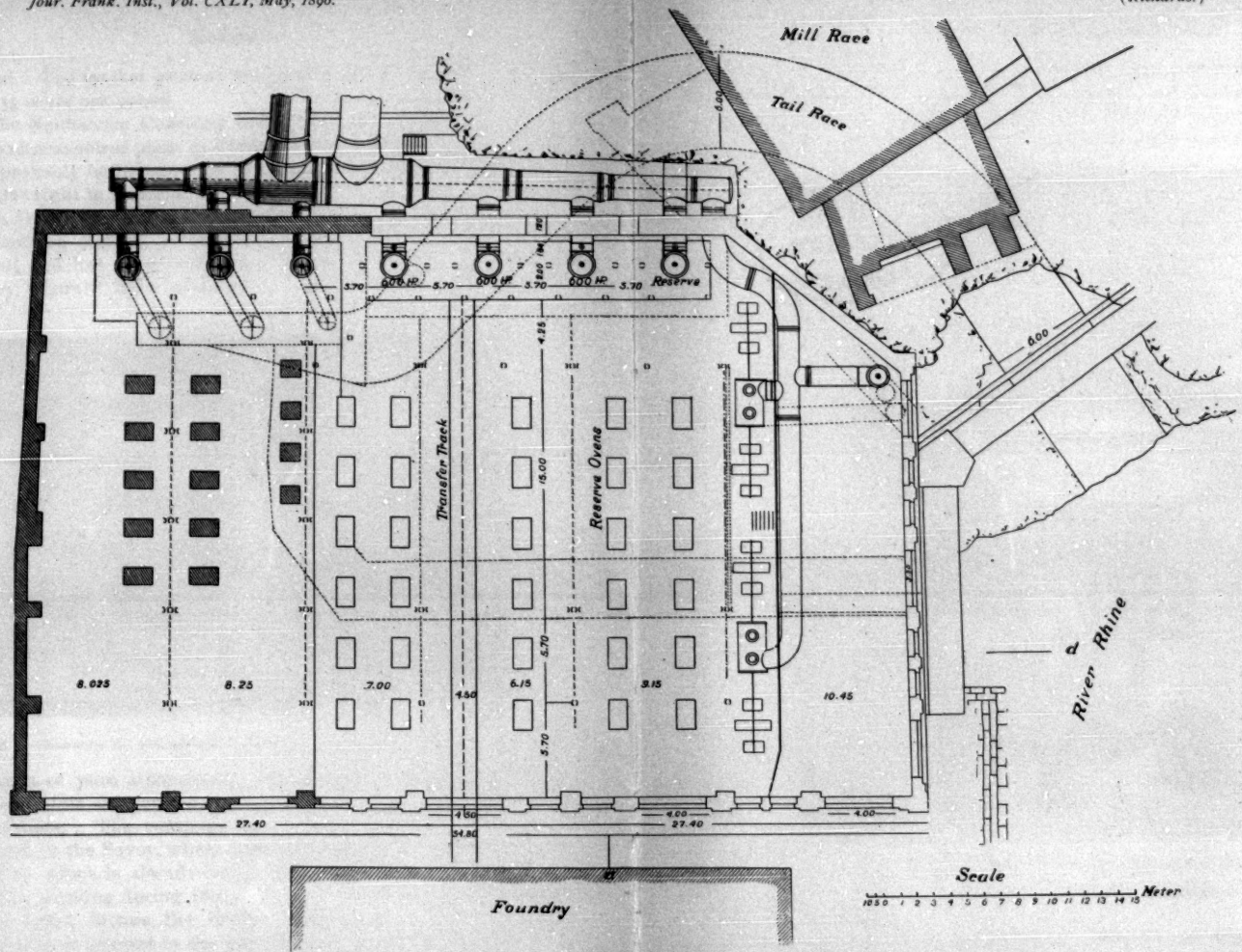

FIG. 6.—PLAN OF THE WORKS OF THE ALUMINIUM INDUSTRIE ACTIEN-GESELLSCHAFT, AT NEUHAUSEN, SWITZERLAND.

pound.' The market price of the Neuhausen metal in 1895 was 35 cents per pound.

The Neuhausen Company has in process of erection a 10,000 horse-power plant at Rheinfelden, near Basle, which will probably be in operation in 1897. It has also acquired a water right in Austria.

In France, the Société Electro-metallurgique Française worked the Héroult process from 1889 to 1893, at Froges (Isère), and has since removed to La Praz, on the Arc, in Savoy, where it has a plant with a daily capacity of 3,000

FIG. 8.—Showing the arrangement of dynamos above the Jonval turbines.

pounds of pure aluminium. The Société Industrielle de l'Aluminium was formed in 1895, to work the Hall process in France. The company has a large works at Saint-Michel, in the Savoy, where 4,000 horse-power are available, half of which is already being utilised, and the other half will be working during 1896.

In Great Britain, the British Aluminium Company has acquired an interest in the Irish bauxite mines and erected a works to make pure alumina at Larne Harbor, near Bel-

fast. The company has purchased water rights at the Falls of Foyers, in Scotland, where 4,000 horse-power will be available. It will operate by the Héroult process, and the capacity of the plant will be about 5,000 pounds per day.

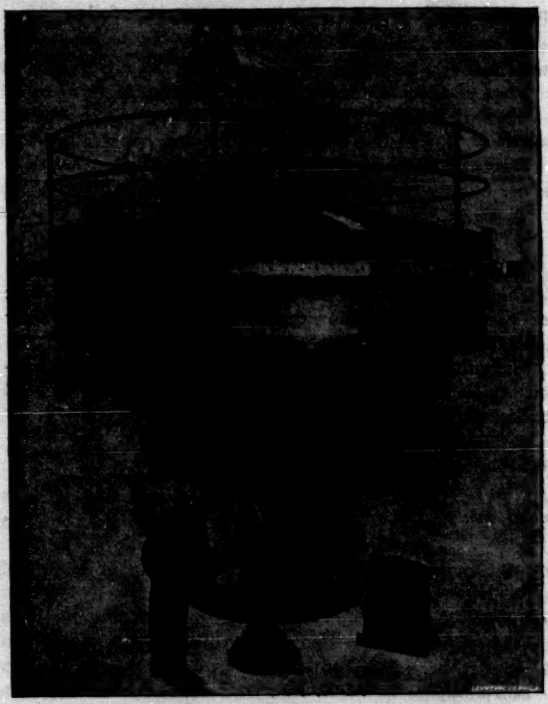

FIG. 9.—The 600 horse-power Oerlikon dynamos used at the Rhine Falls.

This plant is expected to get into operation during the present year.

In Norway, a syndicate of German and American capitalists has purchased water rights at the waterfall of Sarps-

fos, on the estate of Hafslund, between Christiania and Göteborg. There is estimated to be available 10,000 horse-power, and it is purposed to have an aluminium works in operation there by 1898.

A tabular statement of the aluminium works now in operation, their power and daily capacity, is as follows:

	Horse-Power.	*Daily Capacity, Pounds.*
United States:		
New Kensington, Pa.	1,600	2,000
Niagara Falls, N. Y.	1,600	2,400
Switzerland:		
Rhine Falls	4,000	5,000
France:		
La Praz	2,500	3,000
Saint Michel	2,000	2,500
Total	11,700	14,900

This tabulation exhibits a present capacity of 2,500 tons per year; the production during 1895 was approximately 1,500 tons.

The enlargements and new plants at present projected—and which will probably be in operation in 1897, or by 1898 at the latest—are as follows:

	Horse-Power.	*Daily Capacity. Pounds.*
United States:		
Niagara Falls, N. Y.	5,500	7,000
Switzerland:		
Rheinfelden	6,000	8,000
France:		
Saint Michel	2,000	2,500
Great Britain:		
Falls of Foyers	3,000	4,000
Norway:		
Falls of Sarpsfos	5,000	6,500
Total capacity of projected plants	21,500	28,000
" " of plants in operation	11,500	14,500
Total capacity in 1898	33,000	42,500
		Tons.
Annual capacity in 1898 (in short tons)		7,650

When this production has been attained, it is quite probable that the selling price of aluminium will be as low as 25 cents per pound, at which price there are, for practical purposes, only three cheaper metals—iron, lead and zinc.

III. Electro-Thermal Processes.

Following out my classification, I am brought to a decided anti-climax. The present successful methods of producing aluminium have all been described, and this chapter must be confined to a brief allusion to processes which have outlived their usefulness.

In these processes, the current is converted as largely as possible into heat, and, at the temperature obtained, alumina is readily reduced by carbon. The Cowles Brothers

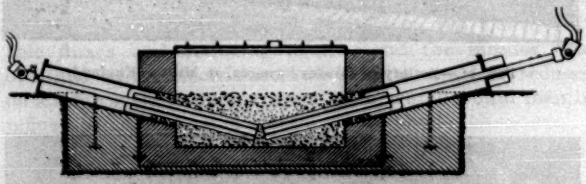

FIG. 10.—Section of Cowles alloy furnace.

used horizontal electrodes, and placed between them the mixture of alumina and carbon, using copper or iron to catch the aluminium and prevent its volatilisation.

Pure aluminium cannot be made in this way, for there is large loss by volatilisation and oxidation, the quality of the metal is vitiated by absorbing carbon, nitrogen and other elements present, and the metal is only obtained in the form of shot, and by an interrupted, and not a continuous, process. *Fig. 10* shows a section of the Cowles furnace, such as was operated for several years at Lockport, N. Y., and at Milton, in England. *Fig. 11* shows the exterior of the battery of furnaces at Milton.

The Héroult alloy furnace was operated for several years in Switzerland and France, and experimentally in the United States, at Boonton, N. J. It is provided with a ver-

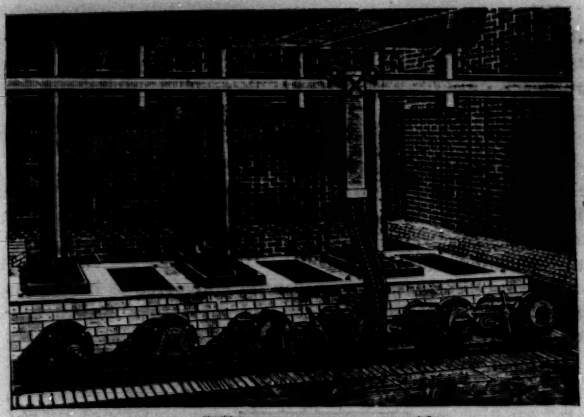

FIG. 11.—Battery of Cowles furnaces, at Milton, England.

FIG. 12.—Suite of five Héroult alloy furnaces, at Froges, France.

tical anode, dipping into a cavity in a carbon-lined box, the carbon lining being the cathode. In this cavity, copper or iron is first placed, then melted by the electric arc playing between the electrodes, after which pure alumina is fed in and similarly melted until it forms a liquid bath above the copper. The greater part of the alumina is then reduced by the carbon present. Alloys only can thus be formed. *Fig. 12* shows a battery of five such furnaces, at the works at Froges, France.

So high a voltage is required to conduct these operations, and the aluminium obtained is so impure, that they cannot compete economically with the gentler and yet much more efficient *electrolytic* processes—which have entirely displaced them. The only possible way in which I can imagine the electro-thermal methods being used again in producing aluminium is in the form of huge electrical furnaces, resembling blast furnaces, in which, with the use of suitable fluxes and reducing agents, and the intense heat obtained by the electric arc, raw bauxite would be reduced on a large scale to impure aluminium, which would then be refined by a chemical or electrolytic method.

STEREOSCOPIC RÖNTGEN SHADOW PICTURES.

By Elihu Thomson

The ordinary single shadow picture, as produced by Röntgen's method, shows the position and dimensions of an object in a single plane only. The thickness, depth or relative positions of objects in a direction perpendicular to the plane of the sensitive plate are not shown or indicated in any way. Thus, in a shadow image of a hand, showing the bones with a faint covering of flesh, there would be no indication of a flexure of a finger or of its being directed upward or downward. Neither is there any indication of the actual position of the bones within the soft integuments, except in the direction of length or breadth. The third dimension is missing.

It may, however, become useful in surgery to know the actual space relations of objects involving all three dimensions. To do this, we may take advantage of the principles of stereoscopic vision as in the stereoscope, which the writer has found perfectly feasible. A moment's reflection will, however, show that stereoscopic shadows are something of a novelty in themselves. A shadow is ordinarily thrown upon a surface, and is seen simultaneously by both eyes. An ordinary shadow having no thickness cannot, of course, be seen stereoscopically. With Röntgen shadow pictures we can, however, secure stereoscopic effects in a very simple way. If we take one such picture of an object or set of objects with the Crookes tube in a certain relation to the objects and sensitive plate, then place another plate back of the objects and obtain an impression upon it with the Crookes tube somewhat displaced laterally from its first position, we obtain two stereoscopic shadow pictures, which may be used to produce prints to be viewed in the stereoscope. The shadow of a coiled spring, for example, obtained in the way mentioned, will, in the stereoscope, show the turns of the spring in relief. The bones of the hand will be seen in space surrounded by the hazy flesh, and if one or more of the fingers be flexed, the degree of flexure will be indicated. A foreign object embedded in the soft tissues would thus have its position with respect to the bones at once declared. As furnishing a background from which depths may be seen or estimated, it is well to place between the object and the sensitive plate a netting of wire with open meshes, which casts a distinct shadow. In such case the stereoscopic shadow images, when viewed stereoscopically, show the objects above the screen and at proper relative distances therefrom. This netting, or screen, also ensures the proper mounting of the pictures in relation to each other; for, should the screen be seen in the stereoscope above the objects, it would indicate that a transposition of the pictures had been made, and that for correct indications to be obtained the error must be remedied.

A number of experiments, made with a view of testing the method above described, have been made by the writer,

and have given very satisfactory results. The skeletons of small animals may be thus examined in relief, and the actual position of objects embedded in solid material discovered. It is conceivable that by the use of a fluorescent screen, and two cathodes placed some distance apart in the Crookes tube, these cathodes receiving discharges alternately, and thus producing two separate displaced sources of Röntgen rays, two stereoscopic fluorescent images may be produced on the screen. If, now, shutters or diaphragms are placed between the screen and the eyes, opened and closed synchronously with the discharges, and alternately with respect to each other, the image will be seen on the screen stereoscopically. In this way, by a rapid examination, the true space relations of embedded objects may be noted.

CHEMICAL SECTION.

Stated Meeting, February 18, 1896.

DR. HARRY F. KELLER, President, in the chair.

A SOURCE OF ERROR IN THE DETERMINATION OF PHOSPHORIC ACID BY THE CITRATE METHOD.

BY FRANCIS BERGAMI.

The citrate method of phosphoric acid determination has been highly recommended for the analysis of superphosphates, basic slag and mineral phosphates by so many chemists of renown that its applicability can hardly be doubted—at least, not to agricultural analysis. Still, some analysts assert that this method has failed to show satisfactory results in their hands, especially on mineral phosphates.

A great number of tests made during the last year have led me to believe that this failure, in many cases, is due chiefly to a delay of the filtration of the ammonium-magnesium precipitate. In making a series of comparative tests, I did not, for a long time, encounter any serious difference

between the citrate and molybdate methods, until once I was compelled, in the analysis of a sample of South Carolina phosphate, to let the ammonium-magnesium precipitate stand over night; while, in all previous cases, excepting some tests on citrate-insoluble phosphoric acid, the filtration had been executed either immediately after the precipitation, or not any later than about three hours thereafter.

The results obtained on this sample were: citrate method, 29·60 per cent.; molybdate method, 28·32 per cent. The test was repeated by the citrate method, with the result 28·48 per cent. As in this latter test the filtration of the ammonium-magnesium precipitate had been executed immediately after the precipitation, I suspected that the high result of the first test had been caused by the delay of the filtration. To ascertain the correctness of this suspicion, several other tests were made, and the fact was thereby established that results obtained by filtration, immediately, or only a short time after precipitation, agree very well with the molybdate method; while those obtained by filtration, after about fifteen hours, are entirely too high. A close observation during those tests showed that the filtrate from the magnesium precipitate, when obtained at once after precipitation, remained perfectly clear for about four hours, after which time a slight turbidity appeared, which increased more and more until, after standing over night, a small precipitate of silica and aluminum and iron oxide had formed. In all filtrates from precipitates which had stood over night, no after-precipitation could be observed.

Of the numerous tests made, the following show the most remarkable figures:

Acidified South Carolina Rock:

	Per Cent.
Molybdate method	16·00
Citrate method (filtration after two hours)	15·92
Citrate method (filtration after fifteen hours)	16·96

Florida Phosphate:

	Per Cent.
Molybdate method	32·16
Citrate method (filtration immediately after precipitation)	32·32
Citrate method (filtration after fifteen hours)	33·92

It has been claimed that, by using concentrated sulphuric acid as a solvent, not only a large amount of calcium oxide, but of aluminum oxide, also, is precipitated. Hoping to at least reduce the error, I treated some samples with 50 cubic centimeters of concentrated sulphuric acid, boiling for thirty minutes, but failed to get any other results than those obtained by the use of hydrochloric and nitric acids.

In the determination of the citrate-insoluble phosphoric acid of acidified mineral phosphates, the danger of getting high results by a delay of the filtration is not so great, as a considerable amount of silica, iron and aluminum oxides is removed by the action of the neutral citrate of ammonium solution at 65° C.; yet, on some samples, results become entirely too high.

From my experience in the citrate method, I have come to the conclusion that the general direction to filter the magnesium precipitate, either right after precipitation or at any later time, holds good only for the determination of the water-soluble phosphoric acid of superphosphates and the insoluble phosphoric acid of animal phosphates, such as bone-meal, and bone-black. In the determination of the insoluble phosphoric acid of mineral phosphates, their superphosphates, and all mixtures containing the same, the filtration of the magnesium precipitate must take place either immediately after the precipitation, or not any later than three hours afterwards, if a contamination by silica and aluminum and iron oxides shall be avoided. With this precaution, however, excellent results can be obtained by the citrate method, provided an appropriate amount of citrate of ammonium solution is used.

According to my experience, the best results are obtained by using 0·4 grams of substance and 75 cubic centimeters of citrate solution in the determination of total phosphoric acid. For the citrate-insoluble phosphoric acid, 0·4 grams of substance and 40 cubic centimeters of citrate solution have proved, in my hands, to give the most satisfactory results.

STANDARDISING OF NORMAL ACID BY BORAX.

By Francis Bergami.

More than thirty years ago, Th. Salzer recommended the use of borax for the alkalimetric measurement of acids, but his proposition attracted very little attention until E. Rimbach[1] published his work on the determination of the atomic weight of boron. Since that time, several other chemists have tried to introduce the use of borax for the standardising of normal acid, but they all propose either methyl orange or litmus as indicators for this purpose. Mr. L. F. Kebler stated some time ago, before the Chemical Section of the Franklin Institute, that methyl orange proved to be of inferior value in his hands, as well as in the hands of other chemists. Litmus enables one to obtain satisfactory results, but it requires a great deal of practice, as the change of color in borax solutions is not as distinct as could be desired for routine work, especially by inexperienced workers. I am, therefore, surprised that so little attention seems to have been paid to the researches of Robert T. Thomson,[2] on larmoid.

Thomson found that larmoid, while its properties as an indicator are nearly the same as those of methyl orange, excels the latter substance by far in regard to sensitiveness, and allows an absolutely correct titration of the alkali in borax solution. A double recrystallisation of the commercial c. p. borax yields a strictly pure product, and, by the aid of this and larmoid as indicator, the standardising of normal acid becomes not only a very convenient, but also an extremely accurate operation.

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[1] *Fresenius' Zeitschrift*, **32**, 526.
[2] *Chem. News*, **51**, 18.

HENRY BOWER.

The Board of Managers reports, with sincere regret, the loss, by death, of one of its members, Henry Bower, who died on March 26, 1896.

Mr. Bower was so conspicuously active and so earnest in the several efforts that have lately been made in behalf of a new building for the Institute, that the Board feels that it is proper to place on record its warm appreciation of its deceased member's zeal and interest in promoting the welfare of the Franklin Institute.

Mr. Bower was born in Philadelphia, in 1833, and was graduated from the Philadelphia College of Pharmacy in 1854. He engaged for a time in the business of broker in chemicals, and, in 1856, began the manufacture of chemicals at Twenty-ninth Street and Gray's Ferry Road, where the works which he established are at present located.

Throughout his active business career he was prominently identified with every movement affecting the growth of the chemical industry in the United States. He was the first in this country to use potash salts as an ingredient of the fertilisers which he manufactured; also, he was among the first—if not the first—to recover, on the large scale, the ammonia from the "gas liquors" of the gas works.

He received from the Franklin Institute, in 1878, the Elliott Cresson Medal, as the first in this country to make pure inodorous glycerine. He received, also, medals for the excellence of his manufactures, at the exhibitions of Vienna, 1873; Franklin Institute, 1874; Philadelphia, 1876; Paris, 1878; and Chicago, 1893.

It was chiefly owing to his representations that the U. S. Census Bureau determined, in the Census of 1880, to have the statistics of the chemical industry reported as a separate branch of manufactures. Mr. Bower was appointed the special agent of the Bureau to collect these statistics for the Census of 1880 and 1890, and the excellence of these reports bears eloquent testimony to the painstaking and thoroughness with which he devoted himself to the work

entrusted to his hands. His intimate acquaintance with the chemical industry of the United States was widely recognised, and the fact that his opinions and advice were frequently sought by the committees of the Senate and House of Representatives in the framing of tariff legislation bearing thereon, affords capital evidence of the extent and accuracy of his knowledge of the subject and of the soundness of his judgment. He was prominent in the councils of the Manufacturing Chemists' Association of the United States, and served this body for many years as secretary and treasurer.

Mr. Bower was elected a member of the Franklin Institute in 1858, was chosen a member of the Board of Managers in 1891, and was continued in this position until his connection was severed by death.

His associates in the Board present this brief tribute to the memory of their late associate to the Institute, whose welfare was always near to his heart, with the suggestion that it be printed in the *Journal*.

By order of the Board,

JOSEPH M. WILSON, *President*.

NOTES AND COMMENTS.*

A CONDUIT ELECTRIC ROAD IN WINTER.

The *Iron Age* has the following comments on the experimental piece of underground electric railway in New York, which has gone through the severe service of the past winter:

The underground road which the General Electric Company installed on Lenox Avenue, New York, has emerged successfully from the tests to which the severe snowstorms of the last month have subjected it. During the violent snowstorm of March 11th the operation of the road did not cease. The snow began to fall about 8 o'clock in the morning and the snow sweeper was started out over the line, but before it could make the complete trip the sprocket wheels of the broom broke, and it was necessary to push the sweeper back into the barn for repairs. Not until 4 o'clock in the afternoon was it ready to go out on the tracks again. Meanwhile the service of the road was conducted without any stoppage, and the cars ran over the unswept tracks

* From the Secretary's monthly reports.

with no greater delay than would ordinarily be caused by considerable slipping of the car wheels on the snow-covered rails. It took about eight or ten minutes longer to make the trip. At some points on the line the snow was swept by the wind into drifts, making it necessary for the motorman to back his car to get the necessary momentum to push his vehicle through the drifted snow. At 4 o'clock the snow sweeper cleared the line of the snow and regular schedule time was again resumed. About 8 o'clock the storm turned to sleet and hail, and, as it fell, covered the rails with ice. Notwithstanding this the cars ran under their usual headway. On the Lexington Avenue Electric Conduit Road a gang of men swept the tracks, and on this line the cars made schedule time while the bad weather prevailed. Throughout the duration of the storm no electrical trouble of any kind was developed either in the conduit or in the cars. The rolling stock of the electric conduit lines of the Metropolitan Traction Company is now undergoing a large increase. Equipment has been started on a number of new cars.

THE SIMPLON TUNNEL.

After a varying lapse of time, the necessity of additional means of communication between the countries north of the Alps and Italy makes itself felt; and just so sure as that the Mont Cenis Tunnel would be followed by that of the St. Gothard, but whether in ten, fifteen or twenty years, could not be foretold at the time, so it was equally certain that the Alps would once more be pierced at the Simplon. The constructors guarantee the necessary installations, the completion of the first tunnel, and the gallery, for the fixed sum of 54,500,000 francs, and the completion of the gallery by turning it into the second tunnel, with a permanent way, for an additional 15,000,000 francs. From the time the traffic begins, ventilators will be used to renew the air of the tunnel and to reduce the quantity of carbonic acid caused by the locomotives. Each train, after passing through, will close automatically the door of the tunnel, and air will be driven into the same by suitable side passages. The need of ventilation from tunnel No. 2 will, of course, have ceased.

The advantages of the Simplon as an international route consist not only in the reduction of distance between Calais and Milan, but specially in the conditions of level, which are much more favorable than in the Mont Cenis and the St. Gothard. The culminating point in the three tunnels is stated thus:

	Meters.
Mont Cenis	1,394·70
St. Gothard	1,154·60
Simplon	705·20

The project of a railway tunnel under the Simplon has occupied the attention of engineers and experts for the last thirty-five years. The scheme has been delayed by the piercing of the Alps at the Mont Cenis and the St. Gothard, but its accomplishment now seems assured. An agreement to this effect was signed between Switzerland and Italy on November 25th last; the

necessary subventions are guaranteed on both sides; and a definite offer from a syndicate of contractors of the highest repute to construct the tunnel for a fixed sum will facilitate the contribution of 40,000,000 francs, which must be furnished by private capital.

The tunnel, which will pass under the massif of Monte Leone between Brigue (Switzerland) and Issela (Italy), will be 19,731 meters long, and its highest point in the interior 705 meters 20 centimeters above the sea-level, with a downward slope in both directions of 1 meter in every 50 towards Brigue and 1 in 143 towards Issela. The principal difficulty in piercing the tunnel will consist in the very high temperature—40° C.—in that part of the route which lies deepest under the mountain, and, therefore, the authors of the project have adopted a new system in piercing it, which is very ingenious. The mountain will be tunneled by two parallel passages at a distance from each other of 17 meters. The first tunnel will be completely finished so as to admit a single line of rails of the normal gauge; the second tunnel will serve as a gallery, and will only be completed so as to admit the double line some years after the completion of the first. This gallery, with its transverse galleries connecting it at every 200 meters with tunnel No. 1, will serve for ventilation, the arrival of ballast trains and other working material, for conducting water at high pressure and laying down electricity for lighting purposes. The transverse galleries will be closed by doors, but the advanced transverse galleries which are nearest the workings, when the piercing of the rock is being pushed forward, will be left open. This door will prevent the current of air from passing through the earlier passages and secure a good ventilation at the actual spot where the workings are furthest advanced.

This draught will then pass through the two advanced transverse galleries and will return by tunnel No. 1. While one of these cross galleries is being pierced, of course there can be no current of air through it; in this case the air will be forced in by means of injectors. The temperature already lowered by the fresh air from the ventilators will further be closed by jets of cold water spray. After each case of blasting the *débris* will be cleared away by hydraulic force, and the Brandt perforators used to pierce the rock will also be worked by the same power. The geological formation of the mountain is favorable to the work, as gneiss chiefly will be met with. The motive force will be supplied at Brigue by the Rhone, and at Issela by the Diveria or the Cairasca. A boring of 700 meters at Berisal above the tunnel will serve for the passage of the water of the Steinenbach, which will supply hydraulic force by its own natural pressure.—*Engineering and Mining Journal.*

THE CARBIDE-ACETYLENE PROBLEM,

which has been the subject of so much and such diverse criticism, is now being made the subject of an exhaustive practical investigation at the hands of a scientific commission composed of electrical and chemical experts selected for the purpose by our enterprising contemporary, *Progressive Age.*

The estimates of cost of production have varied so widely that would-be

investors interested in the new gas have conservatively held aloof, and until the commercial possibilities of the new method have been thoroughly investigated, and established beyond reasonable doubt, such hesitation will continue.

The *Progressive Age*, in undertaking this investigation, deserves the thanks of all who are interested in gas or electric light enterprises, and if the promise held out by its editor be fulfilled, he will have placed the gas and electric fraternity under great obligations.

It only remains for us to add that the experts selected for this responsible work are, on the electrical side of the question, the well-known electrical engineers, Drs. Houston and Kennelly, while the chemical phases of the subject will be reported upon by Dr. Leonard P. Kinnicutt, of the Worcester Polytechnic Institute.

It is stated that the arrangement made on behalf of the experts involves a personal investigation of the works of the Willson Company at Spray, N. C., which will be turned over to them absolutely during the continuance of the proposed tests. W.

GROWTH OF AMERICAN IRON AND STEEL PRODUCTION.

The directory of the iron and steel works of the United States, which is published every two years under the auspices of the American Iron and Steel Association, has just been issued. Its contents bear very striking testimony to the expansion of a department of national industry which has reached proportions unequaled in any other country of the world. Twenty years ago, says the *Boston Herald*, the capacity of the blast furnaces of the United States was 4,856,455 tons; to-day it is 17,373,637 tons. But for the output of 1876, 713 furnaces were required, while for that of 1896, 469 furnaces are adequate. The average annual capacity of the blast furnace of twenty years ago was 6,811 gross tons, while to-day it is 37,044 tons. A still more striking evidence of the revolution that has taken place in the methods of iron production may be found in the fact that the four new furnaces now being constructed for the Carnegie Steel Company will have an aggregate annual capacity of 700,000 tons, or 175,000 tons each. These will be the largest furnaces in the world, and it is significant of the change that has come over the trade since 1894, that while in that year not one new furnace was building in this country, there are to day, besides these gigantic four, twenty other new furnaces either in construction or projected. A steadily decreasing number of blast furnaces use charcoal, the proportion being reduced to less than 6 per cent. of the whole; for the rest, coal and coke serve as fuel. The directory enumerates and describes 505 rolling mills and steel works, the annual converting capacity of all the standard Bessemer steel plants in January last, built and building, being 9,472,350 tons of ingots and direct castings, against 7,740,000 tons in January, 1894. Of the open-hearth steel plants at work or in construction, the annual capacity is 2,430,450 tons, against 1,740,000 tons two years ago. It thus appears that, while the increase in the capacity of the Bessemer steel plants has been 18 per cent. in two

THE MINERAL PRODUCTION OF THE UNITED STATES IN 1895.

The accompanying table, exhibiting the amounts and values of the various mineral products of the United States for the year 1895, we are enabled to present to our readers by courtesy of Mr. R. P. Rothwell, editor, from advance sheets of "The Mineral Industry," Vol. IV, shortly to appear. W. H. W.

MINERAL PRODUCTION OF THE UNITED STATES IN 1894–95.

Compiled for THE MINERAL INDUSTRY, Vol. IV.,

By Richard P. Rothwell, editor of the *Engineering and Mining Journal.*

No.	Products.	Customary Measures.	1894. Quantity. Customary Measures.	1894. Quantity. Metric Tons.	1894. Value at Place of Production.	1895. Quantity. Customary Measures.	1895. Quantity. Metric Tons.	1895. Value at Place of Production.
	NON-METALLIC.							
	Abrasives—							
1	Corundum and emery	Short tons	1,120	1,106	$109,500	385	349	$56,400
2	Garnet	Short tons	1,000	907	35,000	2,065	1,873	93,350
3	Grindstones	Short tons	29,989	27,200	257,596	36,389	33,004	290,378
4	Millstones	Short tons	207	200	4,447	105	95	8,525
5	Tripoli and infus. earth	Short tons	1,693	1,508	22,825	1,788	1,622	26,049
6	Whetstones	Short tons	1,735	1,574	84,450	1,609	1,459	78,303
7	Alum	Short tons	72,000	65,304	2,160,000	75,000	68,025	2,225,000
8	Antimony ore	Short tons	165	150	9,075	1,083	982	37,905
	Asbestos and talc—							
9	Asbestos	Short tons	265	240	4,350	1,010	916	11,400
10	Fibrous talc	Short tons	50,300	45,604	505,000	66,500	60,316	665,000
11	Talc and soapstone	Short tons	21,044	19,087	401,892	18,885	17,129	301,353
12	Asphalt	Short tons	4,198	4,080	75,654	14,300	12,970	300,000
13	Bituminous rock	Short tons	84,190	31,018	148,120	43,778	39,707	143,456
14	Barytes	Short tons	23,758	21,548	95,032	20,255	18,371	99,020
15	Bauxite	Long tons	10,732	10,908	42,928	14,145	14,371	56,580
16	Borax	Pounds	13,140,584	5,962	919,841	13,506,356	6,126	742,850
17	Bromine	Pounds	379,444	172	98,655	394,854	179	102,662
18	Cement, natural hydraulic	Bbls., 300 lbs.	7,813,799	1,064,267	4,425,928	7,694,053	1,047,005	4,557,285
19	Cement, Portland	Bbls., 400 lbs.	611,229	110,877	1,209,440	749,059	135,879	1,460,080
20	Clay, refractory	Short tons	3,975,788	3,061,794	4,050,885	38,750,000	3,401,250	4,500,000
21	Clay, kaolin	Short tons	24,532	22,246	185,160	30,910	28,032	258,431
22	Coal, anthracite	Short tons	a52,010,433	47,183,345	80,879,404	a58,362,985	52,963,538	89,948,699
23	Coal, bituminous	Short tons	a117,865,348	106,903,871	103,788,967	a138,079,466	125,247,053	125,499,488
24	Coke	Short tons	8,495,236	7,706,846	12,654,538	9,927,548	9,006,090	15,258,935
25	Cobalt oxide	Pounds	6,350	3	8,843	6,400	3	8,640
26	Copperas	Short tons	14,807	13,311	104,160	14,118	12,805	69,946
27	Copper sulphate	Pounds	b60,000,000	27,215	2,016,000	45,000,000	20,412	1,350,000
28	Chrome ore	Long tons	2,653	2,697	35,125			
29	Feldspar	Long tons	18,704	19,003	83,465	22,195	22,550	104,082
30	Fluorspar	Short tons	6,400	5,805	58,304	4,000	3,628	36,440
31	Graphite	Pounds	770,846	349	34,689	392,008	178	17,640
32	Graphite, amorphous	Short tons	165	150	1,252	1,100	998	4,700
33	Gypsum	Short tons	301,536	273,468	910,831	298,572	270,804	974,219
34	Iron ore	Long tons	11,880,000	12,070,080	20,790,000	16,050,000	17,221,200	29,662,500
35	Lime	Bbls., 200 lbs.	556,750,000	5,148,320	28,375,000	b60,000,000	5,443,164	30,000,000
36	Magnesite	Short tons	1,370	1,243	7,864	2,200	1,995	14,700
37	Manganese ore	Long tons	11,735	11,924	74,800	14,883	15,121	92,044
38	Mica, ground	Pounds	829,500	377	35,907	750,000	340	31,956
39	Mica, sheet	Pounds	9,000	4	11,108	6,200	3	6,400
40	Mineral wool	Pounds	5,776	5,239	58,936	6,742	6,115	69,481
41	Monazite	Pounds	750,000	340	45,000	1,000,000	862	114,000
42	Natural gas				18,000,000			12,000,000
43	Paints, mineral	Short tons	47,593	43,167	1,011,182	47,084	42,705	1,086,767
44	Paints, vermilion	Short tons	91	83	111,209	118	107	118,190
45	Paints, white lead	Short tons	87,342	78,155	8,445,174	92,000	83,462	8,740,000
46	Paints, zinc oxide	Short tons	22,814	20,697	1,711,275	21,600	20,498	1,598,300
47	Petroleum (crude)	Bbls., 42 gals.	48,527,390	6,158,119	40,762,962	50,552,025	6,420,742	42,547,701
48	Phosphate rock	Long tons	952,155	967,485	2,856,465	831,498	844,802	2,577,643
49	Marls	Long tons	225,000	228,622	607,500	217,700	221,183	587,790
50	Precious stones				150,000			150,000
51	Pyrites	Long tons	107,462	109,192	466,466	81,000	82,296	353,580
52	Salt, evaporated	Bbls., 280 lbs.	11,798,659	1,498,193	5,586,326	12,521,498	1,589,178	5,844,348
53	Salt, rock	Bbls., 280 lbs.	2,541,022	297,576	784,063	1,367,688	173,662	518,740
54	Silica, sand and quartz	Long tons	477,670	485,313	418,612	523,640	532,018	553,128
55	Slate, roofing	Squares	611,776	180,474	2,007,321	645,361	190,277	2,062,289
56	Slate, other manufactures	Square feet	4,395,125	12,966	399,758	3,780,599	11,170	369,062
57	Stone, limestone (flux)	Long tons	3,544,398	3,601,459	2,126,636	3,390,000	3,444,240	2,542,500
58	Stone, marble	Cubic feet	6,331,379	518,532	3,576,853	6,942,533	568,503	4,096,261
59	Stone, onyx	Cubic feet	1,450	110	29,000	800	60	10,750
60	Sulphur	Long tons	441	488	7,056	12,000	12,192	192,000
61	Other building stones				b30,000,000			33,000,000
	Total non-metals				378,877,959			428,996,385
	METALS.							
62	Aluminum	Pounds	817,600	371	490,560	900,000	408	495,000
63	Antimony	Short tons	220	205	30,200	433	393	68,847
64	Copper	Pounds	353,504,314	160,392	33,540,489	386,453,850	175,294	36,944,988
65	Gold	Troy ounces	1,923,619	c59,824	39,761,205	2,265,612	c70,470	46,830,200
66	Iron, pig	Long tons	6,657,388	6,764,572	71,966,364	9,446,308	9,597,449	108,632,542
67	Lead, value at New York	Short tons	160,867	145,906	10,585,048	156,854	142,298	10,132,758
68	Quicksilver	Flasks, 76½ lbs	30,440	1,056	1,095,840	33,978	1,179	1,313,589
69	Silver, commercial value	Troy ounces	49,846,875	c1,550,987	31,408,531	46,331,235	c1,441,087	30,254,296
70	Zinc spelter	Short tons	74,004	67,135	5,200,882	81,858	74,245	5,942,890
	Total metals				194,092,119			240,615,120
	Est. products unspecified				5,500,000			5,000,000
	Grand total				578,470,078			673,881,505

(*a*) Bituminous coal includes brown coal and lignite. The anthracite production is the total for Pennsylvania, Arkansas, and Colorado. (*b*) Estimated. (*c*) Kilograms.

years, that of the open-hearth steel plants has been 28 per cent. Evidence of the production-restricting policy of the nail trust will be found in the fact that while in January, 1892, there were 65 rolling mills devoted in whole or in part to the manufacture of cut nails and spikes, and containing 5,546 nail machines, the number had decreased, by January, 1894, to 55 mills and 5,094 machines, and in January, 1896, to 53 mills and 4,598 machines. A decrease of 948 nail machines in two years, side by side with a great increase of capacity in every other branch of the iron and steel industry, is a fact replete with significance, and to be only partially offset by the increased output of the wire nail works.

It further appears from the directory that there are 74 iron and steel bridge-building works in the United States, 22 locomotive works, 36 iron and steel ship building yards, 64 completed car-axle works and 2 building, 112 completed car-wheel works and 1 partly erected, and 112 car-building works. In addition to these, there are 13 horse nail-works, 82 malleable-iron works, 70 cast-iron and cast-steel pipe works, and 38 wrought-iron and wrought-steel pipe, iron- and steel-riveted pipe and seamless-tube works. These are but part of the many establishments in which the cruder iron and steel materials are taken up and developed into more or less finished products, but even their bare enumeration gives an impressive idea of the magnitude of this branch of American manufactures.

Steel Wool is an interesting product, the subject of a recent German patent, and is intended for use in all cases where sandpaper, emery paper, pumice stone and materials of a kindred nature are employed. In bulk it resembles, both in appearance and to the touch, the hair commonly used for stuffing mattresses and chairs. The ordinary by-product known as steel shavings has for many years been used for rough work, in which the coarser grades of sandpaper are used; but the objections to the use of these shavings for the finer work of rubbing down varnish or paint on woods and for polishing metals were the harshness of, and lack of uniformity in, the threads, and the edges of the shavings being very sharp, thereby cutting instead of polishing; and, being of many different sizes and shapes, would leave an uneven surface. The *Railroad Gazette* says that the idea of making a machine to overcome these difficulties originated years ago in Switzerland with an observing German, who noticed painters gathering the refuse derived from the manufacture of reed for looms, and picking therefrom the finer grades for use in rubbing down wood and metal work generally. Upon examination he found that this residue consisted of flat ribbons of steel, the borders of which were planed off, and before being assorted was an admixture of fine and coarse grades. He readily discovered two defects in the material thus obtained: first, it was impossible to obtain any appreciable quantity of a uniform grade, and, secondly, the temper and quality of the steel were such that only indifferent results could be obtained from its use. Eventually he built a machine for the manufacture of shredded steel or steel threads uniformly fine in quality, but still retaining sufficient cutting propensi-

ties, and so delicate in texture that instead of steel shavings he called it steel wool. Then by carefully studying the temper and quality of steel best adapted to his needs he was enabled to perfect the product. The advantages claimed for steel wool are that it cuts more quickly and uniformly than sandpaper, does not clog or gum, and being both flexible and perfectly homogeneous, adapts itself readily to the shapes of carvings and mouldings.

TECHNICAL NOTES.

Solders for Glass.—The *Pottery Gazette* describes several metallic solders for glass, proposed by Mr. Chas. Margot. The first is an alloy composed of ninety-five parts of tin and five of zinc, which melts at 200°, and becomes firmly adherent to glass. Moreover, it is unalterable, and possesses a beautiful metallic luster. Another alloy, for the same purpose, is composed of ninety parts of tin and ten of aluminum, melts at 390°, is strongly soldered to glass and is possessed of a very stable brilliancy. With these two alloys it is declared to be possible to solder glass as easily as to solder two pieces of metal. The operation is as follows: The two pieces of glass to be soldered can either be heated in a furnace and their surfaces rubbed with a rod of the solder, when the alloy as it flows can be evenly distributed with a tampon of paper or a strip of aluminum, or an ordinary soldering iron can be used for melting the solder. In either case, it only remains to unite the two pieces of glass and press them strongly against each other, and allow them to cool slowly.

Rustless Casting for Iron and Steel.—A French process for this purpose, described in the *Railway Review*, consists in forming on the metal surfaces a double carbide of hydrogen and iron, which is said to be extremely hard and adhesive. The treatment is effected in a pair of gas retorts, set side by side, and raised to a temperature of from 600° to 700° C. The articles in this case are placed in a retort for about twenty minutes, when a current of hydrogen is turned into the retort and kept on for 45 minutes, a small quantity of naphtha being now introduced, the supply of which is kept on for ten minutes. The naphtha is then shut off, a current of hydrogen is turned on for fifteen minutes longer, when the process is finished. All that remains is to cool the retorts down to 400° C., after which the retort lids may be taken off and the product removed. The coating thus produced has a bluish color, and is stated to be so adherent to the metal that a treated bar can be bent through an angle of 45° without disturbing it.

Electric Tanning.—The *Electrical Review* gives the following brief summary of the improvements in this method suggested by Folsing.

The tanning pit has a capacity of 15,000 liters, and is about 80 inches broad and 10 feet long. Electrodes of nickeled copper are fixed to the longer walls of the pit, and in the latter the hides are so suspended that the current has to pass right through them. A current of 12 ampères with

an E. M. F. of 12 volts is used. The tanning matter consists of oak extract, with a little hemlock extract added, both of which are cleared and decolorised by a special electrolytic process. By these means Folsing states that he has succeeded in obtaining good leather in seventy-two hours from light cowhides, in five days from heavy cowhides, and in six days from heavy oxhides.

Solidified Gelatine.—The *Scientific American* gives the following additional details respecting the transformation of gelatine into an insoluble substance, by the action of formic aldehyde, to which several references have been made in these notes, viz.:

Gelatine possesses the curious property of becoming insoluble in contact with formic aldehyde, and, at the same time, of preserving perfect transparency. Gelatine rendered insoluble, or "petrified," to use a more appropriate term, resists water, acids and alkalies. It resembles celluloid, but has the great advantage over the latter of not being inflammable.

The gelatine used is the ordinary article found in commerce. The formic aldehyde is what is commonly called "formol," "formaline" and "tannaline." The commercial product is a 40 per cent. solution of formic aldehyde in water. It is a colorless, syrupy liquid of a pungent odor. The vapor is not inflammable, and it is a powerful antiseptic.

To obtain moulds of statuettes, etc., take 2 pounds of good white gelatine and steep it in a quart of water for a night. The next day the whole is melted over a water bath. For delicate mouldings, the solution is diluted with a little water. The mould, which may be made of plaster, clay, or metal, having been prepared, the formic aldehyde is poured into the melted and slightly cooled gelatine. The whole is well stirred with a wooden spatula to obtain a homogeneous mixture. The latter is then poured into the mould and allowed to cool. After the object is taken from the mould, it is finished by immersing it for a few moments in a concentrated solution of formic aldehyde, or, if it is too large for immersion in the solution, its surface is painted therewith.

Objects obtained with the gelatine alone are transparent and resemble glass. However, by previously adding to the gelatine some finely-sifted zinc white, mixed with a little water and alcohol, and operating in the same way, beautiful imitations of white marble may be obtained.

By mixing the oxide of zinc with appropriate colors, objects of all shades may be obtained, and, by properly arranging the colors, veins, striæ, spots, etc., may likewise be produced. The solidified gelatine may be used for imitating mother-of-pearl, tortoise-shell, amber, coral, etc., and for the manufacture of toys and artificial flowers.

BOOK NOTICES.

A Text-Book on Plain Lettering. By Henry S. Jacoby, Associate Professor of Civil Engineering in Cornell University. First thousand. New York: Engineering News Publishing Company, Tribune Building. 1895.

The author has here endeavored to provide our technical schools with a text-book containing "a detailed treatment of the Roman, Gothic, and some other styles of plain lettering which are suitable for engineering and architectural drawing." The work is illustrated by forty-eight full-page plates, beside numerous illustrations in the text, of which there are eighty-two pages.

The author has taken the Roman alphabet as the basis for his discussion, and has endeavored to reduce spacing to a definite system, using the same scale as in the proportioning of the letters. Chapters I and II treat of the construction and spacing of letters respectively; Chapter III, of titles; Chapter IV, of the selection of styles, and Chapter V, of mechanical aids.

In treating of the lettering on architectural drawings, the author remarks, very truly, that "many of the styles employed in practice approach very nearly to illegibility, including even those on working drawings. Some of them are of such odd, irregular forms, and so utterly devoid of beauty, as to raise the question why they were ever introduced."

The system of round writing, now so extensively in vogue, seems to be entirely unnoticed, either for praise or blame. It cannot be that the author is not familiar with it; it may be that it is not considered as a variety of plain lettering, though it would seem to be at least as nearly legible as the sample of architectural lettering given on page 23, and far more rational and beautiful.

T.

Computation Rules and Logarithms, with Tables of Other Useful Functions. By Silas W Holman, Professor of Physics at the Massachusetts Institute of Technology. New York: Macmillan & Co., and London, 1896.

A surprisingly small part of engineering and scientific computations require to be carried out to more than five places of significant figures. Four and five places suffice for by far the greater part of such work, since they provide for all grades of accuracy up to one-twentieth of one per cent., a limit which is rarely exceeded or required except in special lines of work; indeed, for a large range of engineering work in connection with estimates, specifications and designs of structures, even a slide rule giving but three places of figures is sufficient, and conduces to an enormous saving of time.

But to avoid the really great waste of time and fatigue which attends the use of excessive figures requires the possession of convenient four and five

place tables, and a method of deciding at a glance *what number of places is sufficient for the purpose in hand.* While this matter is of the simplest, yet few but expert computers ordinarily possess any mastery of it. In this respect a very large portion of computation work, done not only by students, but by engineers in practice, is not intelligently performed. This small book has been prepared to meet these two requisites. Pages xii–xiv supply rules for places of figures condensed in very simple form, and supplemented by numerical illustrations. The seventy pages of tables contain four and five place logarithms, four and five place log trig functions, four place natural trig functions, four place square roots, reciprocals and slide wire tables and a few important constants. Rules for the use of logarithms, and all the tables and several pages of explanatory matter regarding the rules for significant figures, precede the tables.

Thus the book is by no means a collection of tables, nor does it profess to replace the more extended tables for specially refined work in geodesy, engineering, astronomy or physics; on the contrary, it is chiefly an attempt to enable the engineer and the student to economise labor through intelligent command of the use of figures, and by providing convenient tables supplementary to the common six or seven place tables.

The book will be found of great value to engineers and engineering students, and, if its contents are mastered, will result in considerable saving of time in ordinary numerical computations. G. F. S.

Rope Driving: A Treatise on the Transmission of Power by Means of Fibrous Ropes. By John J. Flather, Ph.B., M.M.E., Professor of Mechanical Engineering, Purdue University. First Edition. New York: John Wiley & Sons. London: Chapman & Hall, Limited. 1895.

If an author desires to meet the requirements of practical men, and at the same time command a large sale for his book, he should confine his treatment to the use of such mathematical characters and methods as practical men can readily understand.

It is not the name of a thing, in whatever language it may be given, that the practical man most wants and has to deal with; *it is the thing itself.*

Elegant expressions and refinements of calculation are all well enough for the school-room and library, but when we come to applied science we want the things that will apply. What a template or gauge is to a workman, so a rule or formula should be to the one who has the work to do. We believe with the elder Trautwine, that, for practical purposes, simplicity and clearness of statement should be the rule, and mystification wholly avoided.

There are many cases in practice which come nearer solving themselves, if given a chance, as, for instance, on page 131, occurs this statement: "Practically it will be impossible to maintain a constant tension in the rope, so that the amount of sag obtained by calculation is liable to vary with the conditions of service;" which, being true, ought to save a deal of mathe-

matical refinement, which is simply useless in these cases. Now we know, from taking a hand at wire-rope driving, that it is as "tricky as a circus mule." The wind, which knows no law, workmanship that cannot be controlled, and momentum and centrifugal force which have their sway, destroy all refinements of calculation, making the appeal to practice absolutely necessary.

The preface gives promise of thoroughness of search and completeness of detail, saying: "The following treatise has been prepared to supply the existing need of a comprehensive manual of practical information concerning rope driving," etc.

Now the practical man has a right to expect what an author says when he puts up such a sign. There is, indeed, much valuable matter in this handy treatise, but close inspection reveals many repetitions of already existing records. We find, for instance, in "Use of Belting," published in 1877, some thirty-four pages of the same detail, and when we come to rope driving—the specialty of this little volume—we find we have a new play of Hamlet with Hamlet left out.

No reader can believe this omission to be a case of justifiable ignorance, nor simply one of inadvertance. Of course, everything cannot be put in a little book, but yet one cannot help thinking that the word "comprehensive" should cover one of the most largely introduced and commercially useful systems of rope driving as that of the American system invented and developed by Mr. Dodge, of Mishawaka, Ind.

About five years ago a committee of the Franklin Institute of Philadelphia, after careful investigation, gave forth its opinion that the system of transmission of power by ropes, invented, patented and introduced by Mr. Wallace H. Dodge, of Mishawaka, Ind., embodies a contribution to practical engineering worthy of special consideration and award, which was given. Now the book before us speaks favorably of certain features of the American, or wound system, to which the committee referred as the invention of Mr. Dodge, notably his slack-taking device, or tightener, patented June 23, 1885, and his improved or double-wind, patented March 22, 1887.

There is no question of the fact that a large number and a great variety of successful power transmissions by the Dodge system are in actual use, of the performance of which there can be but one opinion expressed, and that a favorable one. Considered from the standpoint of practice, therefore, a book on rope transmission of power, is not complete without a full and clear embodiment of the American, or wound system, together with the various details and examples which have been devised and installed by Mr. Dodge.

The author of a treatise, professedly "comprehensive," owes his readers a fulfilment of that promise, and where literature and examples on this subject are abundant, as we know them now to be, there is no excuse for their absence from its pages.

J. H. C.

Modern Copper Smelting. By Edward Dyer Peters, Jr. Seventh edition. Rewritten and greatly enlarged. New York and London: The Scientific Publishing Company. 1896. Price, $5.00.

The present edition of Dr. Peters' "Modern Copper Smelting" is practically a new work. The progress in this branch of metallurgy within the past few years has been so great, and, in certain directions, so radical, as to require that the book should be substantially rewritten. The ground to be covered also is so extensive, and the amount of special information demanded so considerable, that the author has very wisely called to his assistance the services of a number of specialists having intimate knowledge of special branches of the modern science and art of copper smelting. These contributions add greatly to the value of the book, which no one who is interested in the subject can afford to dispense with. Among the special chapters above referred to, is one on the electrolytic refining of copper, a branch of the art which, of late years, has grown to imposing proportions. W.

Modern Stone Cutting and Masonry. With special reference to the making of working drawings. By John S. Siebert, C.E., and Frederic Child Biggin, B.S. New York: John Wiley & Sons. 1896.

The authors treat the subject with special reference to everyday engineering and architectural practice. Chapter I treats of the tools of the mason and stone-cutter, the shape and finish produced by them, the classification of masonry and kindred practical matters pertaining to the handicraft.

Chapter II treats of stone-cutting and masonry proper, and comprises a number of examples of typical engineering and architectural constructions, worked out in more or less detail, with especial reference to the student's needs.

The examples include buttresses, arches, intersecting arches, arch culverts, railroad-bridge masonry, canal-lock masonry, and architectural stonework. W.

Dont's for Consumptives, or the Scientific Management of Pulmonary Tuberculosis, is the title of a book which, under the authorship of Dr. Charles Wilson Ingraham, is to be issued by the Medical Reporter Publishing Company, of Rochester, N. Y.

The complete work of thirty-five chapters is devoted exclusively to the general management of pulmonary invalids, no reference whatever being made to drug treatments.

The object of the author is to supply the physician with a practical work, and, at the same time, by eliminating technical terms, reduce the text within the easy comprehension of the intelligent patient. The author claims that "a good understanding of his condition is the best remedy for the consumptive." With this book in the hands of his patient, the physician will be relieved of a multitude of details which attach to the successful management of such cases. Special attention has been given those chapters pertaining to the destruction of tubercular infection. W.

Shop Kinks and Machine Shop Chat. A series of over 500 practical paragraphs in familiar language, showing special ways of doing work better, more cheaply and more rapidly than usual. By Robert Grimshaw, M.E., etc. (With 222 engravings.) New York: Norman W. Henley & Co. 1896. Price, $2.50.

To the machinist, whether shop-owner or operative, this collection of ingenious suggestions for saving time and labor will prove a welcome addition to his list of handy reference books, and should prove specially valuable as a guide to be consulted whenever an unexpected difficulty is encountered, or a sudden emergency is to be met. The matter of the book, in fact, is made up largely of ideas that have been conceived and put in practice by a number of the foremost machine establishments, to meet their own requirements, and it covers so great a variety of topics that it is scarcely conceivable that any machinist should not find something in its pages that he could adapt with advantage to his own personal needs.

The book is profusely illustrated and the engravings are unusually well executed. W.

A Pocket-Book of Marine Engineering Rules and Tables. For the use of marine engineers, naval architects, designers, draughtsmen, superintendents, and all engaged in the design and construction of marine machinery, naval and mercantile. By A. E. Seaton, M. Inst. C. E., etc., and H. M. Roanthwaite, M. Inst. M. E., etc. (With diagrams.) London: Charles Griffin & Co., Limited. New York: O. Van Nostrand Co. 1894.

The *raison d'etre* of this pocket-book, as set forth by the authors, recites the fact that the existing pocket-books for engineers deal only in a general or incidental way with many matters of the first importance to those engaged in marine engineering, and that much of the meager information thus imparted is so scattered as to be difficult of useful reference, or is obsolete. The authors accordingly have set themselves to the task of preparing a pocket-book of rules, memoranda, tables, etc., especially adapted to the needs of this special class, in which marine engineering questions are dealt with thoroughly. The book appears to be admirably adapted for its intended purpose. W.

REPORT

of a Committee of Judges appointed by the Board of Managers to examine a memoir submitted in competition for the Boyden Premium.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 29, 1896.

To the Franklin Institute.

GENTLEMEN:—We, the undersigned, committee of judges, appointed by you to report upon a communication received from the Secretary of the

Franklin Institute in relation to the Boyden Premium, have examined a competitive memoir from a person under the pseudonym of "Massis."

We find that the method suggested in this memoir might be made competent to determine the relative velocities of luminous rays in air, but is not competent to determine the relative velocities of any physical rays other than luminous rays, and, therefore, does not, in our judgment, comply with the terms of the Boyden requirement.

Very respectfully yours,

A. E. KENNELLY,
H. W. SPANGLER,
GEO. F. STRADLING.

Received and adopted at the stated meeting of the Institute, held March 18, 1896.

WM. H. WAHL, *Secretary.*

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, April 15, 1896.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 15, 1896.

JOS. M. WILSON, President, in the chair.

Present, 62 members and visitors.

Additions to membership since last month, 19.

The Actuary reported a vacancy in the Board of Managers, caused by the death of Henry Bower, and transmitted, by instruction from the Board, a memoir of the deceased which the Board had adopted. The memoir was accepted and referred for publication.

A special election, held to fill the vacancy thus created in the Board, resulted in the choice of Mr. W. N. Jennings, to fill the unexpired term of the deceased member.

Mr. John H. Cooper read a paper descriptive of the Worthington Self-Cooling Condenser, illustrated with the aid of lantern slides. Discussed by Mr. James Christie, and referred by vote to the Committee on Science and the Arts for investigation and report.

Mr. Cooper also presented a brief *résumé* of certain data of performance of American two-cylinder locomotives.

This subject evoked an interesting discussion, in which Mr. Samuel M. Vauclain, Superintendent of the Baldwin Locomotive Works, Mr. Henry F. Calvin, and the author, participated.

The President then introduced Prof. W. Lascelles-Scott, of London, England, who gave, by invitation, an interesting account of some investigations of the alleged discovery, by Mr. Keeley, of a new force. At the close of his remarks, the meeting passed a vote of thanks to the speaker.

Adjourned.

WM. H. WAHL, *Secretary.*